THE ELEMENTS OF SANITARY SCIENCE.

A HAND-BOOK

FOR

DISTRICT, MUNICIPAL, LOCAL MEDICAL AND SANITARY OFFICERS, MEMBERS OF LOCAL BOARDS AND MUNICIPAL COUNCILS, AND OTHERS.

BY

SURGEON-MAJOR C. J. McNALLY, M.D.,

D.P.H. CAMB.; FELLOW OF THE MADRAS UNIVERSITY;
FELLOW OF THE CHEMICAL SOCIETY; ASSOC. COLL. OF STATE MEDICINE;
CHEMICAL EXAMINER TO GOVERNMENT AND PROFESSOR OF CHEMISTRY,
FORMERLY PROFESSOR OF HYGIENE, MADRAS MEDICAL COLLEGE;
ACTING DEPUTY SANITARY COMMISSIONER.

MADRAS:
PRINTED AND PUBLISHED BY
THE SUPERINTENDENT, GOVERNMENT PRESS.

LONDON: H. K. LEWIS.

1889.

PREFACE.

THIS Hand-book is addressed primarily to the educated classes, in the hope that it may afford them information which is important to all—as life and health are important—and which may serve to benefit them, and, through them, the great uneducated masses of the people. Many persons, who are otherwise well educated, have been taught little or nothing of the science of health, and suffer individually thereby; while general sanitary authority is vested in corporations whose members often feel the need of a guide to the principles of Public Sanitation, and who are, for want of it, unable always to spend the public money to the best advantage of the public.

Those who desire to obtain more than a superficial acquaintance with the subject of Sanitary Science should begin by acquiring some knowledge of elementary chemistry, biology and physiography.

A few portions of the book may not be clear to those who possess no such preliminary knowledge; but the author trusts that the greater part of it may be perused with advantage even by those who have not had the benefit of any scientific training.

It has been his object to expound the *principles of sanitation* (while not omitting useful practical details, with special reference to Indian requirements), and to avoid dogmatic statements; for any appeal to educated and thoughtful men must be addressed to the intellect, and these pages are an appeal to the more educated, thoughtful, and influential members of the community to awaken to the vastly important actualities of sanitary neglect and to the immense possibilities of sanitary progress.

Authorities are generally quoted in foot-notes; statements not so authenticated are either well-known facts, or those for which the author is responsible. General acknowledgments are due to the writings of Cornish, H. King, various Sanitary Commissioners and others in India, and to those of Parkes, Farr, Simon, Buchanan, Corfield, Wilson, Klein, and many others in England, as well as to those of Pasteur, Koch, and some other foreign workers and authors.

The author is conscious of some faults in this little work, which has been put together during furlough and in the few leisure intervals of official life; many others no doubt exist of which he is not conscious. He hopes, however, that they are not such as will impair its general usefulness. Although written for the Madras Presidency, it applies equally—with the exception of parts of the chapter on *Sanitary Law* dealing with local Acts, which differ in each province—to all parts of India; and it is nearly as applicable to tropical countries generally. It may therefore prove of some use in England to medical and civil officers and others who are preparing to go to India or other tropical regions.

MADRAS,
October 1889.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER XII.

APPENDIX.

CHAPTER I.

INTRODUCTION.

Health and Disease.

Good health is the greatest of blessings, and is universally recognised as the one indispensable quality of happiness for animated beings. In all countries and in all conditions, inquiries after health form the habitual salutation of friends, and "health and long life" their kindest wish.

By general consent, fame, rank, wealth, and all else which men most do covet and cling to are as naught compared with health. This, then, being admittedly the most valuable of all possessions, we would naturally conclude must be the most jealously guarded and preserved by men; yet such is far from being the case. Men habitually squander health and life as though they valued these least of all things. Life is proverbially sweet, yet the great majority of mankind perish prematurely from more or less preventable disease; few die from accident or the natural decay of age. In India alone more than two millions of human lives are annually sacrificed to preventable disease and more than ten millions are rendered temporarily or permanently miserable by it.

Ignorance and apathy are the keys of this apparent contradiction—ignorance of the origin and nature of disease and of the means of preventing it; apathy, a result of poverty and debility, which holds to acquired habits, or fears the magnitude and inconvenience of reform. Few persons, even among the otherwise highly educated, truly realize the enormous amount of misery, inefficiency, and death which result from preventable disease, or credit the large degree to which individuals and communities can control their own health and happiness.

The most famous civilized nations of antiquity gave much care to sanitation in various ways, and owed not a

little of their pre-eminence to this. The successes of Grecian arms and the glories of Grecian art were prepared and fostered by the great attention which the Greeks paid to physical culture. The Romans not only rivalled them in this, but in the magnificent aqueducts, sewers, and recently discovered subsoil drains in Rome itself and in many places throughout old Roman provinces, they have left still visible monuments of the importance which they attached to a pure and abundant supply of water, to the removal of filth, and to dryness of soil. Several ancient religions and laws give other instances of practical sanitary knowledge and regulations. The fall of the Roman empire, however, followed by an era of political instability, led to a forgetfulness of the primitive laws of health and a lapse into habits of uncleanness, which fully account for the terrible habitual mortality which prevailed and the awful epidemics which periodically swept over Europe during the middle ages. Mankind had once again to be taught by dire experience, and from its teachings gradually arose the fabric of modern hygiene.

A few facts may now be cited from the recent history of England to show what can be accomplished in a comparatively short period by sanitary reform. Fifty years ago, England was little more advanced in public sanitation than India is at the present day. Impurity of air, water, and soil was the rule everywhere ; vaccination was not general ; sanitary law was all but unknown ; no facilities existed for towns or districts to borrow capital for public improvements ; there was no general registration of vital statistics. The Registration Act of 1837 was the *magna charta* of sanitary reform in England, and the able and logical reports of the Registrar-General (Dr. Farr's first annual report appeared in 1839) did more than anything else to place England in the foremost rank of healthy nations. Activity in the prosecution of sanitary works became prevalent all over the country, and the good effect of measures, such as improvements in drainage, sewerage, water-supply, food, dwellings, is abundantly shown by the great and progressive decline of mortality which immediately followed them. Numerous instances are cited in the reports of the Registrar-General and of the Medical officers of the Local Government Board, which show that such a local decline invariably followed local sanitary improvements. The money borrowed for sanitary works in Great Britain between 1848 and 1886 amounted to no less than £130,000,000, in addition to large sums

provided out of local revenues and enormous private expenditure. But this money was well invested. The average duration of human life in Great Britain has been largely increased,* and this, coupled with the prevention of sickness, has added enormously to the productive power of the population and the wealth of the nation. The yearly death-rate of London, which closely approaches the average English death-rate, and was 50 per 1,000 in the past century, steadily diminished until it reached but 22·4 in the ten years 1871–80 and 19·3 in the five years 1881–85, and several English districts have now a death-rate below 15 per 1,000—a rate which was not long since regarded as utopian. Considering the amount of preventable disease which still exists and the amount of sanitary work which is practicable in the way of improving local conditions and habits and preventing the spread of disease, it must be regarded as possible for the mortality to be reduced in some places to about 12 per 1,000.

Similar results can undoubtedly be attained in India, and India has this general advantage over England, that she possesses proportionately few large towns. The introduction of purer water-supplies has caused a large reduction of cholera mortality in Madras, Calcutta, and some other towns; the great improvement of health among soldiers and prisoners in cases where a faulty dietary has been corrected is well known; and other instances might be mentioned where sanitary measures have been followed by a reduction of mortality in India.

It has been reckoned that nearly four-fifths of the entire registered mortality of India is due to mitigable or preventable diseases.† The statistics of the general population are unreliable owing to imperfect registration, but those of municipal towns are more to be depended on. In the municipal towns of the Madras Presidency for the five years 1881–85 the average *registered* annual mortality exceeded 30 ‡ per 1,000, and nearly half of this mortality was attri-

* The mean duration of life (expectation of life at birth) was, in round numbers, by Price's Northampton Life Table corrected (1762) about 30 years, by Milne's Carlisle Table (1789) 38 years, by Farr's English Life Table, No. 1, (1841) 41 years, and by Dr. Ogle's New English Table (1871–80) 43 years. It is now considerably longer.

† Army Sanitary Commission, 1886.

‡ The true rate was probably about 40.

buted to the four causes—cholera, small-pox, fevers, and bowel-complaints; the first two of which ought to be entirely preventable and the two latter preventable to a great extent. Besides these, other preventable diseases account for a portion of the remaining mortality. Altogether there is no doubt that Indian mortality can be very largely reduced and that the happiness and prosperity of the people will increase with their longevity. It is necessary, however, that the excessive birth-rate should be reduced at the same time; this subject will be treated of in several places further on.

Poverty is undoubtedly a great bar to sanitary improvement, and bad sanitary conditions beget poverty, so that poverty and sickness re-act upon each other and tend to diminish the vital power of a people and their capacity for improvement. Hence the task of initiating sanitary improvements must devolve upon the governing, educated, and wealthy classes of a community; and, apart from the higher motive of philanthropic duty in relieving the sufferings and ameliorating the lot of their poorer, more ignorant and dependent brethren, it is manifestly their personal interest to ward off disease from their own doors. Not rarely do epidemic diseases, such as cholera or small-pox, whose breeding places are in the midst of dirt and poverty, leave their endemic haunts among the poor and seek out their victims in the neighbouring houses of rank and opulence. Then, indeed, spasmodic efforts are inspired by terror, and money is often frittered away in fruitless efforts to stay an epidemic, which wiser forethought would have prevented.

Such hurried whitewashing and cleaning up can do little to purify places, where earth, water, and air have been habitually defiled, to establish effective control over unwholesome food supplies, or to reform the insanitary habits of generations. Deliberate training and preparation are as necessary to protect a country against the invasions of disease as to fortify it against the inroads of an enemy, and all experience proves that sanitary preparations protect from endemic as well as from epidemic diseases. Sanitary preparations should, therefore be steadily prosecuted at all times, and we may rest assured that as we lessen our mortality from ordinary endemic diseases, so do we diminish our liability to the ravages of epidemics; but, while urging that sanitary improvement should be prosecuted steadily at

all times and not only fitfully under the influence of panic produced by unusual outbreaks of disease, it should not be forgotten that it is a wise axiom not to destroy existing arrangements, faulty though they may be, without having provided efficient substitutes.

The duties of the sanitarian require a combination of reason and firmness, tact and skill. It is only by earnest and sustained exertion that any permanent improvement can be effected, and constant vigilance is required to prevent deterioration and relapse. Unwearying attention to details is a necessary condition of success in sanitary administration, and the most indomitable perseverance is needful for the pioneers of sanitary work. Zeal must, however, be tempered with discretion, and in dealing with ignorant or interested opposition, tact and compromise may largely succeed when haste and impracticable thoroughness must totally fail. Small and partial measures can often be carried where larger and more comprehensive ones are impossible, and small and partial measures of improvement are not by any means useless. They are steps on the road. Every single case of disease prevented or mitigated is so much gained and may be the cause of preventing thousands of other cases. As every little loophole which is barred against the entrance of an enemy strengthens the citadel, so does the stoppage of every single channel by which disease may enter or be propagated strengthen the structure of public health.

Public health is one of the most serious concerns of the State. Bad sanitary conditions lessen the working power of an individual by constantly lowering his strength and energy, by causing periods of sickness when he cannot work at all, and by shortening his life. It is a fact which hardly needs demonstration that, other things being equal, a healthy long-lived community has enormous advantages over an unhealthy short-lived one, inasmuch as it possesses a larger proportion of working adults. This alone would ensure its supremacy in any commercial or military struggle But furthermore its incapacity from sickness must also be much less, and its people must be more vigorous at all times. It is, therefore, apparent that good sanitation is an important element of national prosperity, and that, on economical grounds alone, it is to the advantage of communities and governments as well as of individuals to do all in their

power to promote it.* Indeed, the economical value and national importance of State medicine can hardly be over-estimated. In the words of the President † of the International Congress of Hygiene at Vienna in 1887—"Man is the most precious capital of the State and of society in general; every individual life represents a certain value."

The duty of the State and of the influential and wealthy classes to initiate and promote sanitary improvements being acknowledged, an important consideration yet remains: one of the most essential factors in the sanitary progress of a community is the co-operation of the people themselves. The efforts of Government and of enlightened local authorities are often rendered more or less abortive by the passive resistance of the mass of the population. This resistance cannot usually be regarded as culpable; it is but the natural outcome of ignorance—more often a misfortune than a fault—and it is the first duty of every medical and sanitary officer, from highest to lowest, of every member of a municipality or local board, and of every other person who possesses the requisite knowledge, to assist in dispelling the darkness of ignorance which degrades the people and renders them a constant prey to misery and disease. Local illustrations are most apt to impress uncultivated minds; for instance local outbreaks or single cases of a disease, in which it can be shown that the incidence of the disease is dependent upon some form of sanitary negligence, are certain to impress them more than facts which are not obvious before their very eyes.

Combined action and public legislation are not only requisite for the execution of large sanitary undertakings, but they are equally necessary to protect individuals and communities from disease in the daily affairs of life. It is the interest of every individual not only himself to obey sanitary precepts, but to see that his neighbours do likewise. A single individual may, by his own wise conduct, ward off much disease and misery from himself; but he cannot live apart from his fellows, and he is very apt to suffer disease,

* A systematic examination or "sanitary survey" of all towns and large villages and of unhealthy districts by well-qualified officers, such as was recommended recently by Surgeon-General G. Bidie and such as has been proposed and partly carried out in some cases by the Local Government Board in England, would be of the greatest value as a guide to permanent improvement and the most useful employment of local funds.

† The Crown Prince of Austria.

and perhaps death, entirely owing to their sanitary sins. They may poison his air, his water, and his food, or sow broadcast the germs of communicable diseases : he is forced to share the results of their folly. Similarly the insanitary acts of one individual may affect a whole community; therefore, every individual who commits a sanitary offence is a public criminal of the worst kind, for his hand is against every man. Hence the necessity of punitive sanitary law.

Besides those objections to sanitary improvement which are the result of ignorance, indolence, or fatalism, one other deserves special notice, because it is the only objection of a scientific nature which has ever been advanced. A partial application of Darwinian principles has led to the conclusion * that sanitation interferes with natural law, and that degradation of the human race must be the result of a suspension or abrogation of disease as a cause of natural selection and the survival of the fittest. It may be pointed out that this objection would apply to curative more aptly than to preventive medicine. Its confutation, however, must rest upon evolutionary principles. The fact is certain that insanitary conditions affect not only the weakly, whom they kill, but the strong, whom they debilitate, and, in this way, they tend to produce a depraved race; whereas improvement in sanitary conditions, according to the doctrines of the influence of environment and improvement under improving conditions, must tend to improve the race. It might be conducive to improvement—unless the race were totally wiped out by the process—if individuals attacked by diseases which permanently enfeebled them were all to die, and thus be prevented from propagating a feeble offspring; but it is a fact that, for each one who dies, a considerable number recover with more or less damaged constitutions; such diseases being unchecked must, therefore, necessarily tend to cause degeneration of the race. On the other hand, the aim and effect of sanitation is to prevent the enfeeblement of individuals by disease, and not only to act thus, in a negative way, by preventing deterioration of the race, but also to act positively towards the improvement of the race by improving their surroundings and their mode of life. Practical illustrations of the truth of these doctrines may be observed everywhere. Persons and communities who live under the best sanitary conditions are notoriously the most

* A conclusion which has partly been supported by the great authority of Herbert Spencer.

vigorous; those who live in the country are more vigorous than others of the same race who live in towns under inferior sanitary conditions; those who live on high lands, where the soil is comparatively dry and the air and water pure, are more vigorous than those who live on ill-drained low lands; the unhealthy life conditions of the inhabitants of malarious tracts in South Canara and the Wynaad have produced a puny, stunted, short-lived and degenerate race, who compare unfavorably in every way with the inhabitants of healthier localities in the neighbourhood. Drainage and improved ventilation have enormously reduced the prevalence of scrofula in many parts of England to the obvious benefit of the race. From these and innumerable other examples of the kind the conclusion is inevitable that the aim of the sanitary evolutionist should be not to deprave the race by adapting it to unhealthy surroundings, but to elevate it by improving its surroundings.

The intimate nature and mode of propagation of diseases have been matters of more or less fanciful conjecture to the ancients and were very imperfectly understood until quite recently. It will be necessary to give in this place only a very brief and general account of them. The following simple classification of diseases is convenient from a sanitary point of view, with regard to their origin, propagation, and prevention:—(1) physiological diseases; (2) microbic diseases; (3) parasitic diseases.*

1. *Physiological Diseases* are those which are due to alterations of function or of structure, the result of causes other than microphytes or parasites. Diarrhœa due to congestion resulting from external cold or from the irritation produced by indigestible food is an example. The most important causes of these diseases are hereditary weaknesses or tendencies, faults in diet, exercise, or clothing, climatic influences, and chemical poisons.

2. *Microbic (or microphytic) Diseases* are due to extremely minute vegetable parasites, often called "disease germs" or "microbes."

These microscopic plants belong to the lowest grade of the vegetable kingdom, but they have many qualities in

* Although these headings are not unobjectionable in a scientific and etymological sense, they have been adopted as on the whole expressive and convenient. Billings' classification most nearly resembles this, but he adds a class of Hereditary diseases.

common with the higher plants. They may multiply in two ways—(1) by dividing into two, each half becoming a separate structure, or (2) by seeds. These organisms are so very small that they can only be seen by the aid of a very powerful microscope. The bacillus of anthrax is one of the largest and best known; it has the shape of a minute rod; 1,250 of these rods, placed end to end, would measure only one inch, and it would require no less than 18,000 of them, placed side by side, to measure an inch. The seeds of such organisms are almost inconceivably small and are contained in the air and water everywhere, ready, like the seeds of larger plants, to grow when placed in favorable conditions. These seeds are much more permanent and difficult to destroy than the organisms themselves. Most microphytes are not causes of disease and will not grow in the living body. Those which do grow in the body and so cause disease may often also grow out of the body, or be cultivated artificially in the laboratory. Microphytes multiply very rapidly under favorable circumstances, and vegetables of this nature are the causes of fermentation and of decomposition by growing in the fermenting or decomposing substance. For example, if we take some fresh toddy, and after boiling it to destroy any germs it may accidentally contain, seal it up in a perfectly clean glass bottle, it will remain clear and unchanged for any length of time. Now if we open the bottle and so admit outside air (which is full of floating germs) into it, the toddy soon ferments, froths up, and becomes turbid; it also loses its sweetness and becomes intoxicating. What occurs is this. The germs of certain microbes, which readily multiply in liquids containing sugar, having entered with the air, grow rapidly in the toddy; during their growth they decompose the sugar of the toddy into carbonic acid gas (which causes the frothing) and alcohol or spirit, which remains in the liquid. The turbidity which occurs is due to the presence of innumerable little cells or bladders, which may be easily seen under the microscope and are the microbes which cause this kind of fermentation. Similarly fruit, or vegetables, or meat are often preserved for food in tin pots from which air (containing germs) is excluded. But if the pots be opened and the contents be exposed to the air, they become infected by floating germs, and decomposition soon sets in. If a particle of any decomposing substance be examined under a powerful microscope, myriads of microbes may be seen growing in it. It is thus that the specific microbes, which

cause various diseases, grow in the blood or tissues of the body and produce disease either by forming poisons (as the alcohol was formed in the toddy) or by destroying the tissues which they grow upon.

Infectious, contagious, and specific diseases generally belong to this class. Each of these diseases has its own specific germ or microbe; and, to prevent the spread of the disease, the efforts of the sanitarian must be directed to destroy its seeds, or, at all events, to prevent their dissemination. Such disease germs may enter into the body in the air which is breathed, the water or food which is swallowed, and rarely through the skin.

3. *Parasitic Diseases* are due to animal parasites. These may be of large size, such as common intestinal round worms, very small, such as intestinal thread worms, or so minute that they cannot be seen without the assistance of a microscope, such as the itch insect and the blood worm. Some parasites live on or in the skin. Internal parasites may enter the body by their eggs or immature forms being swallowed with water or food and at least one (guinea-worm) is believed to enter through the skin.

Having now acquired some ideas of the nature of disease, we shall, in the following chapters, consider in detail the circumstances which affect the preservation of health.

CHAPTER II.

FOOD AND DIET.

Physiology of Food.

The uses of food are: firstly, to supply material for building up the tissues of the body, in early life, and for repairing them and making good their waste (which may be compared to the wear and tear of machinery) throughout the whole course of life; and, secondly, to supply fuel for warming the body and for its internal and external work.

For the repair of the tissues a comparatively small quantity of food is required. The substances of which the body is composed may be divided into three chemical groups: (1) *inorganic*, or mineral, including water, which is a constituent of all the solid tissues as well as of the fluids, the earthy salts of which the bones are mainly composed, and the more soluble salts which are contained in the fluids of the body; (2) *nitrogenous*, comprising all the active vital tissues, and remarkable for the presence of nitrogen in the composition of all the substances contained in it; and (3) *fatty*—a certain amount of fat or oil being contained in most of the tissues, and masses or layers of fat serving to pad and protect internal organs, to lessen the friction of muscles, to form a warm covering, like a blanket, under the skin, and to serve as a store of energy which may be drawn upon and consumed when food is deficient. Each of these groups must be represented in the food which is needed for the repairs of tissue. Fresh meat is such a food, and the seeds of leguminous plants, as dhal, supply largely the requisite materials. Fat may be formed in the body from the nitrogenous and other constituents of food; but only a small quantity is thus formed in the human body: most of the fat has to be supplied in food.

A comparatively large quantity of food is required to be slowly burnt in the system and thus to supply energy for the action of the heart and the muscles of breathing and of the intestinal tract, nervous power, animal heat, and other

internal work, as well as for the external muscular work of the body. Carbonaceous food (containing carbon united with hydrogen and oxygen) is employed for this purpose; but nitrogenous food (containing carbon, hydrogen, oxygen and nitrogen) may also be used as fuel. Oxygen is taken by the lungs from the air and carried in the blood to all parts of the body. It serves to produce energy by oxidizing (uniting chemically with) the elements of food materials, a process exactly similar to, but slower than, the ordinary combustion of fuel in the air.

Waste materials are removed from the body (1) by the lungs—the burnt-up carbon of fuel-food passing out in the breath, combined with oxygen, in the form of carbonic acid gas, and the hydrogen, also combined with oxygen, as watery vapor; (2) by the kidneys—waste nitrogenous substances, salts, and water passing out in the urine; (3) to a small extent by the skin, which supplements the action of the kidneys and lungs; and (4) undigested portions of the food are evacuated by the bowels.

Constituents of Food.

The chemical constituents of food substances have now to be described with special regard to their use for the nutrition or repair of the tissues and as fuel for the production of animal energy.

The constituents of food may be classed as follows:—

1. Water.	4. Oils.
2. Salts.	5. Starchy substances.
3. Albumenoids.	6. Condiments.

Water is an essential constituent of all food and, taken partly in solid food and partly as drink, should form at least four-fifths of the total weight consumed. Milk, which is the natural food of infants, contains 88 per cent. of water. Most raw food grains contain one-eighth their weight of water, and, when boiled, more than half. Water forms about three-fourths of the weight of lean meat; and succulent vegetables contain much more; melons, for instance, 90 to 95 per cent. The use of water is to soften and dissolve the solid constituents of food, so that they can be digested and absorbed.

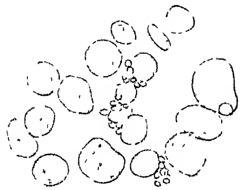
Mineral ingredients, or salts, are contained in all foods, and constitute the whitish ash which remains when a food substance is burnt. Rice is the only important food in

Plate I.

Microscopic Appearance of Starches (× 250).

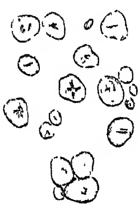
1. WHEAT (*Triticum vulgare*).
2. RICE (*Oryza sativa*).
3. JOAR—CHOLAM (*Sorghum vulgare*).
4. RAGI (*Eleusine corocana*).
5. CHICK-PEA—BENGAL GRAM (*Cicer arietinum*).
6. HORSE GRAM (*Dolichos biflorus*).
7. DHAL (*Cajanus Indicus*).

Plate I.

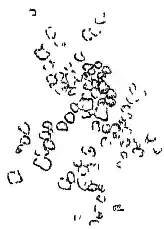


1

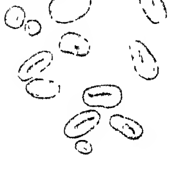
2



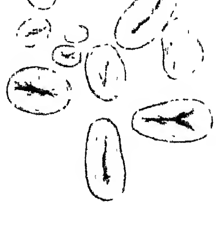
3



4



5



6

7

which they are very deficient. Calcium and potassium phosphates, salts of organic acids, and traces of iron salts are the most important salts contained in food. Common salt (sodium chloride) is also essential, and, being contained in only small proportion in most foods, has to be added separately. Some of these salts are necessary constituents of the fluids of the body and also help to liquefy albumenoids in digestion and to nourish bone and nervous tissues. The salts and acids contained in fresh vegetables and fruits are useful in preventing scurvy. About half the quantity of mineral matter required is contained in the food substances, the other half being added in the form of common salt.

Albumenoids, also termed *nitrogenous* or *flesh-forming* substances, are the most important and the most apt to be deficient of the solid constituents of food. They are contained in very different proportions in various articles of food, and are most abundant in animal foods and in the seeds of leguminous (pod-bearing) plants. Albumenoids are not only indispensable for the nutrition and repair of the tissues, but they may also take the place of carbonaceous foods (oil and starchy constituents) and serve as fuel for the production of energy.

Oils, or fats, consist of carbon and hydrogen with very little oxygen. A moderate quantity of oil in food, though not essential to life, is very conducive to health and proper nutrition. Most articles of food contain a little oil, but it is usually necessary to add more. Animal are more readily digested than vegetable oils. Oil is a most valuable source of energy, being nearly two-and-a-half times as powerful as starch.

Starchy constituents, including sugar and some other substances, are sometimes termed *carbohydrates*, because they contain, united with carbon, such a proportion of hydrogen and oxygen as together would form water. *Starch* is the principal carbonaceous food of mankind. The staple grains, which form the great bulk of human food, are composed principally of starch; arrowroot and sago consist entirely of it; and some other vegetable foods contain considerable quantities of it. Starch exists in plants in minute granules, which can only be seen by the aid of a microscope, and which differ in size and shape in each plant. To render starch easily digestible and fit for food these granules have to be burst by cooking. By strong heating,

as in parching grain, starch is converted into *dextrin* which is more soluble and easily digested. *Sugar* has nearly the same value as starch as a source of energy. *Cellulose*, of which the fibres and cell-walls of plants consist, belongs to this group of substances. More or less of it is taken with all vegetable foods; but it is indigestible and passes away through the bowels.

Condiments or *flavoring constituents.*—Besides the essential constituents of diet, various substances are employed to give flavor and variety to food, to stimulate the digestive organs, and to act as antiscorbutics. These commonly consist of seeds, fruits, leaves, or other vegetable products containing essential oils, or of acid substances, as tamarinds, limes, vinegar.

Requirements of Diet.

Proportions of Alimentary Constituents.

Diet requisites vary to some extent with circumstances which will be mentioned further on. To understand the principles of diet we must, firstly, consider the relative quantities or proportions of food constituents, and, secondly, the absolute quantities which are required. We have seen that the main functions of food are to supply (1) nourishment and (2) energy. Thus considered the important food-constituents may be divided into two groups: (1) nitrogenous substances or flesh-formers (albumenoids), and (2) carbonaceous substances (oily and starchy constituents).* In estimating the value of a food, it is convenient to consider all the carbonaceous constituents as if they consisted of starch only. For this purpose the weight of oil should be multiplied by 2·4, to get its equivalent of starch, and this should be added to the weight of the starchy constituents. Thus the *proportion* between the nitrogenous and carbonaceous ingredients may be easily observed. In a good diet the ratio should not be less than 1 : 6; that is,

* In many works on food the values are given as proportions of *carbon* and of *nitrogen*. The following are the data required to make the necessary conversions: (1 oz. = 437½ grains):—

	Per cent.	Grains per oz.	
Albumenoid contains ...	15·8	69	of N.
Do. do. ...	53·5	234	of C.
Oil contains	79	346	of C.
Starch contains	44·4	194	of C.

for every six parts of carbonaceous there should be at least one part of nitrogenous material. This rule is founded upon practical experience as well as upon physiological considerations.*

A second general rule, though one of less importance than the first, based on similar grounds is, that *at least a similar proportion* (1 : 6) *should exist between the oil* (reckoned as starch) *and the total carbonaceous constituents* reckoned as starch.†

To state the matter in the usual way, the following figures show the smallest relative quantites of nitrogenous and oily to starchy constituents which may be contained in a good diet.‡

Nitrogenous ...	3	Oily	1
Starchy ...	15		

While smaller proportions than these of nitrogenous and oily substances should not be contained in a good diet, there

---

* The proportions in the average diet of badly-fed English artizans and laborers (E. Smith) is 1 : 7·5, and in that of well-fed workers (Sir L. Playfair) 1 : 4·2. The mean of these is 1 : 5·85. The proportion in Moleschott's average diet is 1 : 4·44; in Playfair's diet of workmen belonging to English companies 1 : 5·25; in Letheby's mean of researches by physiologists, for idleness 1 : 7·5 and for routine work 1 : 6; in author's examination of diet of Madras sepoys 1 : 9; Madras long-term convicts (H. King) 7·2; Madras Famine Code lowest diet, with rice as staple, 1 : 9·5, and with cholam as staple, 1 : 7·2; in Church's bare sustenance diet 1 : 4·34, and moderate work diet 1 : 5·34.

† The proportion of oil to total carbonaceous matter in the diet of well-fed English laborers (Playfair) is 1 : 4·2 and of company workmen 1 : 5·2; in Moleschott's average diet 1 : 3; in diet of Madras sepoys (author) 1 : 5·6; of Madras convicts (King) 1 : 4·7; of badly-fed English workers (E. Smith) 1 : 14·9; and less than 1 : 50 in the lowest Famine Code diet.

‡ In Moleschott's well-known diet for ordinary labor, which is usually accepted as a model standard, the proportions of nitrogenous and oily constituents are much larger. Sir Lyon Playfair's diet of company workmen and Church's diet for ordinary labor give lower porportions than Moleschott's. The three diets are here compared, the absolute quantities in ounces being given :—

	Nit.	Starch.	Oil.	Salts.
Moleschott	4·6	14·3	3	1·1
Playfair	5·1	22·2	2·2	0·9
Church	3	12·5	1·4	...

The following diets for laboring convicts in Indian jails may also be compared, the absolute quantities in ounces being given (H. King) :—

	Nit.	Starch.	Oil.
Madras	3·64	18·34	2·05
Bengal	2·55	18·70	1·08
Bombay	3·36	17·78	1·50
Panjab	3·93	19·37	1·59

are certain circumstances under which the proportions of these alimentary constituents may be increased with benefit. Such circumstances are youth, habit, climate, work, disease.

Youth.—A large proportion of nitrogenous and oily constituents are required in the diet of the young and growing to afford material for building up the tissues of the body. Human milk, which is the natural diet of infancy, contains nitrogenous and carbonaceous constituents in the proportion 1 : 3·5 and nearly half the weight of the carbonaceous constituent is oil.* As age advances these proportions may be gradually reduced, especially as regards oil; but it should not be forgotten that, until growth is complete, the diet of young persons ought to contain a larger proportion of nitrogenous and oily constituents than that of adults. A frequent error in feeding children is to give them too large a proportion of starchy food, and thus, though their stomachs may be over-distended with an excessive quantity of food, they are ill-nourished and unhealthy. Children also need a sufficient supply of lime salts in their food to afford material for the formation of their bones and prevent the occurrence of rickets.

Habit may cause life to be supported wholly upon nitrogenous and oily foods, to the exclusion of starchy materials. The inhabitants of cold and wild regions, where animal flesh and fat are almost the only food obtainable, afford instances of this habit. Persons unaccustomed to the use of starchy food do not easily digest it; and those whose staple food is starch may find it difficult to digest sufficient quantities of oily and nitrogenous materials to supply its place. Therefore great and sudden changes in the habitual proportions of food constituents are to be deprecated.

Climate.—It is obvious that the portion of the food which is required to maintain animal heat by its slow combustion in the body need be much less in hot than in cold climates and in hot than in cold weather. Hence a large proportion of oily food is particularly useful in cold climates, as it supplies the necessary fuel in a less bulky and more readily digestible form than its equivalent of starch.

Work.—When unusually hard work has to be done an addition of oily food, or the substitution of oil for some of the starchy constituents of diet, is very useful for the same

---

* Deduced from Payen's Analysis.

reason as that above stated. A proportionate increase of nitrogenous food is necessary at the same time, because carbonaceous food cannot be properly digested without such an admixture.

Disease.—The proportion of alimentary constituents in diet is often of great importance in the treatment of disease; but a consideration of this subject belongs properly to the physician and cannot be discussed here.

Diets may be *faulty by relative excess or deficiency* of certain constituents. A common fault in the diets of both rich and poor in India is a deficient proportion of nitrogenous matter. The consequence is that, to supply a sufficient quantity of this for the ordinary nutrition of the body, a large excess of carbonaceous matter is habitually consumed. The effect of such a diet is to produce improper nutrition of the vital tissues, with an undue deposit of fat, frequent indigestion, and sometimes fatty degeneration of organs or diabetes. For instance, rice contains only 1 part of nitrogenous to 11 of carbonaceous material; and, as the lowest proportion for a good diet is 1:6, it follows that, in a diet consisting exclusively of rice, and if only a bare sufficiency of nitrogenous aliment is taken, nearly double the necessary quantity of carbonaceous material must be swallowed at the same time. In other words, two pounds of rice have to be taken to do, in an imperfect manner, the work of one pound of a correctly constituted food.

We have seen that nitrogenous may take the place of carbonaceous constituents in diet; therefore relative excess of digestible nitrogenous food is not likely to be hurtful, unless the total quantity of food be too large.

Excess of certain salts may occasionally be injurious, as when excess of lime salts induces stone in the bladder. On the other hand, deficiency of such salts may lead to rickets in children, and to defective nutrition of nervous and other tissues. Deficiency of common salt may cause indigestion and encourage the breeding of intestinal parasites.

A due proportion of oil is not so essential as a sufficient proportion of nitrogenous material in food, because some oil can be formed in the body from other constituents of food. Only a limited quantity, however, can thus be formed in the human body, and a certain proportion of oil is therefore required in every good dietary. An excess of

oil, particularly if it be vegetable, and if the total amount of food be in excess, is apt to produce dyspepsia and diarrhœa in persons not accustomed to it; but, if taken habitually, it is likely to cause obesity. Oil is particularly required as an adjunct to food consisting of starchy and albuminous substances which are deficient in it.

Quantity of Food required.

The daily quantity of dry food materials required by an adult, during idleness, is about 0·15 oz. for each 1 lb. weight of the body, or, in other words, $\frac{1}{105}$ of the body weight. A man weighing 105 lbs. and doing no active work will therefore require 1 pound of dry food constituents daily. At least 2 oz. of this should be nitrogenous material, $\frac{3}{4}$ oz. oil (which is equivalent to 1·8 of starch), and ·7 oz. salts. The daily quantities in a subsistence diet for an idle man weighing 105 lbs. would thus be in ounces :—

Nitrogenous ...	2	Oily	$\frac{3}{4}$
Starchy ...	$11\frac{1}{2}$	Salts	$\frac{3}{4}$

If oily constituent cannot be given, the quantity of starch should be increased to $13\frac{1}{4}$ oz.*

These quantities must be increased or diminished in proportion to body weight.

There are other circumstances besides the weight of the body which may modify, more or less largely, the quantity of food which is required. These are youth, work, habit, climate.

Quantity of food in relation to age.—During growth much more food is required, in proportion to weight of body, than in adult life. It has been already mentioned that this food should also be more nitrogenous and oily. The total daily quantity of dry food constituents needed by an infant

---

* The following low diets may be compared with this. Constituents in ounces :—

	Nitrogenous.	Carbonaceous.
Famine Code (rice)	1·85	17·6
Do. (cholam)	2·31	16·58
E. Smith : diet required to avert starvation (reduced for weight of 105 lbs.)	2	15
Playfair : subsistence (do. do.)	1·4	9·2
Church : bare sustenance (for 105 lbs. weight).	2·12	9·25

may be stated as 0·6 oz. for every 1 lb. of body weight, or about $\frac{1}{26}$ of total weight. At 10 years of age the quantity will be about 0·3 oz. per 1 lb., or $\frac{1}{50}$ of total weight; and, after puberty, about 0·2 oz. per 1 lb., or $\frac{1}{80}$ of total weight, until growth is complete.*

Quantity of food in relation to work.—The relation between food and work is of the highest importance. It is a matter of daily experience that increased work requires increased food. Men, like other animals, lose weight, by consuming the tissues of their own bodies, if their food does not bear a sufficient proportion to the work which they do, until ultimately they succumb to disease or become unable to accomplish so much work. As fuel, in a steam-engine, may, by its combustion, supply mechanical energy, so may food, in the animal body, by a chemically similar, though slower, combustion, supply mechanical energy; and the animal body is a more perfect machine than the steam engine: for while in the latter only $\frac{1}{10}$ of the theoretical energy of the fuel can be utilized as mechanical work, fully $\frac{1}{5}$ of the energy of man's food can be realized.†

The ordinary measure of work is the *foot-ton:* the work done in raising a weight of one ton to a height of one foot. It has been calculated by physiologists that the daily "internal work" of an average man's body is equal to about 260 foot-tons; his food has to provide for this as well as for keeping up the temperature of the body and for the amount of external work which is done. The quantity of food required by a man doing a minimum amount of work has been already stated; we have now further to consider what increase is necessitated by increased labor.

The mechanical value ‡ of the various food constituents may be reckoned, in round numbers, for one ounce of each,

	Foot-tons.
Albumenoids and starchy substances ...	140
Oil	350

* These deductions are made from Letheby's figures.

† Helmholtz.

‡ The mechanical or dynamic value of food substances has been calculated from the amount of oxygen which is required to convert their carbon into CO_2 and the hydrogen into H_2O. It has also been determined experimentally (Frankland) by measuring the quantity of heat evolved by the complete combustion of weighed quantities.

Thus the additional amount of food required for any additional amount of work may be easily calculated, always remembering that five times the theoretical amount of food must be taken, as only $\frac{1}{5}$ of its potential energy is actually realizable.

Two foot-tons for each pound weight of the body is a fair day's work for a man, three foot-tons per pound is hard labor. From the data given above, it may be calculated that for 200 foot-tons of work a man may properly receive the following addition to his subsistence diet * :—

	oz
Albumenoids	1
Starch	5
Oil	$\frac{1}{2}$

Habit.—Most people who can afford it eat considerably more food than they require and assimilate only the more easily-digestible portions of their food. If the food of such overfed persons be suddenly diminished to about their actual needs, they will be partially starved at first, owing to their being unable to digest all the nutriment of their food. Again, grain-eaters, who are accustomed to distend their stomachs with large quantities of food, containing far too much starch, though perhaps not a sufficiency of albu-

---

* The following scales of diet requisites for work may be compared :—

Letheby's mean of researches by physiologists (reduced here for a body weight of 105 lb.), quantities in ounces :—

	Nitrogenous.	Carbonaceous.
Idleness	1·9	14
Ordinary labor	3	18
Active labor	4	24

Church's diets for weight of 105 lb. :—

	Nit.	Oil.	Starch.	Total Carb.
Bare sustenance	2·12	0·75	7·52	9·25
Moderate work	2·95	1·41	12.53	15·78
Hard work	3·63	2·51	11·19	16·95

If we take the *differences* between the diets (quoted by H. King) of prisoners doing light or no work and those at hard labor, we obtain the following figures for different provinces :—

	Nit.	Starch.	Oil.	= Foot-tons available ($\frac{1}{5}$ of potential)
Madras. ...	1·2	3·3	0·6	168
Bengal ...	0·4	1·39	0·2	64
Bombay ...	0·25	2·37	0·77	107
Panjab ...	0·87	3·70	0·28	148

menoids, will at first suffer from hunger if their diet be changed for a less bulky, although more nutritious one.

Climate.—In cold climates, as already mentioned, more food is required than in warm climates, because more is needed to maintain the heat of the body, supposing the amount of work done to be the same.

The effects of deficiency of food, if sudden and complete, are hunger, followed by great weakness, and wasting of the fat and other tissues of the body. Under favourable circumstances a person may live for about three weeks without food, but death generally occurs in less than half that time. Exhaustion supervenes very rapidly if hard work be done without food. In the author's experience a case occurred where a working party of sepoys, marching through a mountainous country, had to perform very hard labor for many hours, without being able to obtain food. Several of them fell into a state of collapse, resembling that of cholera; but they were speedily restored by suitable warm nutriment and rest. Partial and continuous deficiency of food will be considered in the appendix on Famine.

Excess of food is habitually taken by many people without any very obvious ill effects, the unused excess passing away by the bowels. Great excess, however, leads to an unhealthy plethoric condition, with digestive troubles, and a tendency to structural degeneration or other diseases of various organs, for instance, of the liver or the kidneys.

Food Materials.

Hitherto we have been considering the more theoretical aspect of food and diet: we have now to see how the scientific principles of diet are to be practically applied.

Natural food substances may be classified thus:—

1. Staple food-grains.
2. Leguminous grains.
3. Animal foods.
4. Oils and fats.
5. Starches and sugars.
6. Vegetables and fruits.
7. Condiments.

In the following paragraphs some account is given of the principal substances contained in each of the above classes:—

Staple Food-grains.

Grain of some kind forms the principal article of food everywhere in India. The staple grains nearly all belong

to the order of grasses (N.O., *Gramineæ*), often termed *cereal* grains. The staple grain of each place is that which is most largely cultivated and cheapest in the locality. Thus, in Southern India, rice is extensively cultivated and forms the staple food of large populations in the coast districts, along the course of the large rivers, and wherever else there is an abundant supply of water for irrigation; ragi forms the staple in many places where the soil is moist, but not sufficiently so for rice; while, on drier lands, some other kind of millet, such as cholam or kambu, forms the staple food. These cereal grains, which may fitly be called "primary foods,"* form the great bulk of the food of people of all religions and castes, rice being usually preferred by Brahmins and the wealthier classes. It is mainly in the choice of secondary foods that religious and caste influences are noticeable.

These grains contain too small a proportion of albumenoids and of oil to form perfect foods, and they consequently require the addition of other food stuffs which are rich in albumenoids and oil. Rice is particularly deficient in both respects, as well as in the proportion of mineral matter which it contains. Wheat contains a sufficiency of albumenoid and mineral matter, but not sufficient oil. The millets, which include most other cereal food grains, are inferior to wheat in the proportion of albumenoids which they contain, but superior to it in the proportion of oil. In India the millets, taken all together, are more important than either rice or wheat because they form the staple food of larger populations. The ash (mineral residue) of cereal grains consists largely of phosphoric acid and potash, which are two of the most valuable mineral ingredients of food. The following table shows the percentage composition of the principal staple food-grains of India.†

---

* Cornish on Food and Prison Dietaries, 1864.

† This table is taken from Church's *Food-Grains of India*, 1886 (from analysis by Forbes Watson and Church), but the author's figure for albumenoids in rice has been substituted as more nearly representing the average composition of that grain. In recent analyses made by the author of good samples of several food-grains obtained in Madras the proportions of albumenoid were almost identical with those here given, except in the case of cholam, in which they were considerably, and in ragi, in which they were slightly, higher.

Grain (husked).	Albu-menoid.	Starch.	Oil.	Ash.	Water.	Fibre.
Rice	6·5	79·1	0·6	0·6	12·8	0·4
Koda	7·0	77·2	2·1	1·3	11·7	0·7
Ragi	7·3	73·2	1·5	2·3	13·2	2·5
Gundli	9·1	69·0	3·6	3·5	10·2	4·6
Maize	9·5	70·7	3·6	1·7	12·5	2·0
Joar (cholam)	9·3	72·3	2·0	1·7	12·5	2·2
Bajra (kambu)	10·4	71·5	3·3	2·0	11·3	1·5
Kagni	10·8	73·4	2·9	1·2	10·2	1·5
China (varagu)	12·6	69·4	3·6	1·4	12·0	1·0
Wheat	13·5	68·4	1·2	1·7	12·5	2·7
Amaranth	13·7	58·4	6·0	5·2	11·9	4·8

In the preparation of these grains for food, *husking* or removal of the outer coverings of the seeds is the first operation. This is commonly accomplished by beating the dry grain with a pestle and winnowing away the husk.

The method of cooking varies with different grains and in different places, but there are four principal recognised methods: (1) the grain is boiled whole in a considerable quantity of water, which is strained off as soon as the grain is sufficiently cooked: it swells by absorbing water and about doubles in weight; the *cunjee water* is drank separately, fresh, or after it has become acid by fermentation on keeping; (2) the grain is pounded or ground in a hand-mill, and the meal or flour thus obtained (or sometimes the whole grain) is boiled with a moderate quantity of water, so as to form porridge, or with less water to form pudding; (3) the meal or flour is made into a thick paste with water and formed into cakes, which are baked on a pan; (4) the grain is *parched* by stirring it in hot sand and sifting it out. A mixture is often made of cholam, ragi, varagu or other grains, or of ragi or millets with rice, especially for cooking in the form of porridge or pudding. In whatever way the grain be cooked it is eaten either hot or cold along with salt and various condiments and with or without ghi or oil, dhal, meat, vegetables, sugar or other subsidiary articles of food.

Attention may here be usefully directed to a few practical points connected with these staple grains.

Rice is eaten by about one-fourth of the population in Southern India.* Eight parts of husked rice yield five of

* More than 30 per cent. of the population of the Madras Presidency according to the Famine Commission.

cleaned rice, and two parts of the latter, when boiled, yield five parts.* Rice should be kept for at least six months after it is harvested, because new rice is unwholesome and apt to cause indigestion and diarrhœa. Partly boiled paddy keeps better and is probably more wholesome, though less white in color, than raw *table* rice. New rice can be cooked in about half an hour, yields a thick cunjee water, and does not keep well after cooking. Old rice takes about twice as long to cook, yields a thin cunjee water, and keeps good for more than 24 hours after cooking.†

The insufficiencies of rice as a food have been already pointed out; and persons who live mainly upon it are ill-nourished and weakly. It is, however, very digestible and agreeable and forms a suitable habitual food if its deficiencies be made good by combining it with sufficient quantities of substances which are rich in albumenoid, oily, and mineral ingredients. Animal foods, leguminous grains, oils, and fresh vegetables are best suited for such a purpose.

Ragi is superior to rice in the proportion of albumenoid, oil, and especially of mineral matter, which it contains. In its proportion of albumenoid and oil it holds a position intermediate between rice and the other millets. If combined with a sufficiency of albuminous and oily substances it forms an excellent staple food. It is, however, apt to disagree at first with persons unaccustomed to its use, and, as a rule, it is eaten only by the laboring classes. In parts of Mysore, Hyderabad, and many Madras districts it is much used. Ragi possesses the advantage of keeping good for an indefinite period, and it has been found perfectly preserved in grain pots which have been disinterred after having lain buried for more than a generation. Ragi is commonly eaten as porridge or pudding; but it is sometimes cooked in the following way. The ground grain is mixed with cold water and exposed to the sun for a day or two, until it becomes sour, when it is boiled and allowed to cool. It then forms a jelly with a pleasant acid flavor.

The other millets mentioned in the foregoing table are koda, gundli, joar (cholam), bajra (kambu), kagni, china (varagu). The composition of these grains varies a good deal in different samples; but (with the exception of koda, which

---

* Church. † Dr. Short quoted by Cornish.

is about equal to ragi) they may be taken as averaging about 10 per cent. of albumenoid, 3·5 per cent. of oil, and 71 per cent. of starch. Thus the ratio of albumenoid to carbonaceous constituent would be nearly 1:8, and of the oil to total carbonaceous as 1 : 9 5, so that a moderate addition of albuminous and oily substances is required to render the millets perfect foods. They are certainly far superior to rice and but little inferior to wheat as staple food grains.

Wheat is an important food in parts of the Panjab, North-Western Provinces, Central Provinces and Bombay. In Madras it is not habitually eaten except by Europeans and some wealthy Mahometans. It contains a sufficient proportion of albumenoid (1 : 5·3), but is deficient in oil (1 : 25) to serve as a complete food.

Wheat is ordinarily prepared for food by being ground into flour, the flour being separated into *suji*, which is the finest and most starchy part, *maida* the medium, and *ata* the coarsest. The outer indigestible coats of the grain form the bran, which is rejected, but *ata* contains some of the finer inside coats and is richer in albumenoid, oil, and salts than *suji* or *maida*. The latter are used for making sweetmeats.

Ata is commonly made into a paste with water and fashioned into cakes (chapaties) which are baked at a moderate heat. Biscuits are wheaten cakes baked at a high temperature. Bread is a spongy form of wheaten cake, which is more easily digestible than the chapati, and is generally made by adding fermenting toddy, or yeast, to the paste (dough) formed by kneading flour and water. The bubbles of gas liberated during fermentation form little cavities in the bread and render it light and porous. 100 parts by weight of flour should yield 136 parts of good bread.

Amaranth is the only staple grain here mentioned which does not belong to the order of grasses. The plant is generally cultivated in mountainous parts of the country and its seed often forms the principal food of the inhabitants of those regions. In the Deccan these seeds are eaten on fast days by Hindus, and are usually parched and taken with sugar. The green leaves of amaranth are used as a vegetable. This grain is the most nutritious of all the staple grains here mentioned and alone contains a proper proportion of albumenoid and of oil.

4

Leguminous Grains.

Leguminous food-grains, often termed pulses, are the seeds of pod-bearing plants, such as the various kinds of dhal, gram, beans and peas, and form valuable and much used food materials. They are principally remarkable for the large proportion of albumenoid which they contain and for their comparative indigestibility. For the former reason they are extremely useful in supplementing the deficiency of albuminates in cereal grains; but for the latter reason they can be eaten only in very limited quantity. Dhal, especially if not well cooked, is a frequent cause of diarrhœa and is often passed undigested by the bowels. It is particularly likely to disagree with persons unaccustomed to its use.*

The digestibility of these grains is promoted by admixture with easily-digestible foods and by careful and prolonged cooking after being soaked or ground.†

Besides being very rich in albumenoid, the pulses are rich in mineral matter (containing much phosphorus and sulphur), and, although they generally consist largely of starch, some of them contain much oil instead of starch.

The quantity of pulse consumed daily by non-flesh eaters is usually 2 to 4 oz., and it is not advisable that the latter quantity should be much exceeded.

The following table ‡ gives the percentage composition of some of these grains:—

Name of pulse.	Albumenoid.	Starch.	Oil.	Ash.	Water.	Fibre.
Chick pea (Bengal gram) ...	21·7	59·0	4·2	2·6	11·5	1·6
Mung gram ...	22·7	55·8	2·2	4·4	10·1	4·8
Pea	23·6	57·5	1·5	2·5	11·8	1·0
Lentil	24·9	59·5	1·3	2·2	11·8	1·2
Ground-nut ...	24·5	11·7	50·0	1·8	7·5	4·5
Soy bean ...	35·3	26·0	18·9	4·6	11·0	4·2

* Kasari dhal (*Lathyrus sativus*, vetchling) which is used in parts of North-Western Provinces and Oudh, when habitually eaten in large quantity causes paralysis of the legs. Some kinds of *Phaseolus*, as *Phaseolus lunatus*, also appear occasionally to have poisonous properties.

† Church. ‡ From Church's *Food-Grains*.

The pulses are prepared for food in various ways: (1) the grain is soaked in water until it swells (for 24 hours or less), or, even without soaking, it is husked and boiled with condiments and eaten, generally with the addition of vegetables, as a curry, along with the staple food; (2) it is ground, mixed with condiment and made into cakes or small balls, which are often fried in oil or ghi, and also eaten with staple food; (3) it is parched, in the same way as rice and other grains, and thus is often used as food by laborers and travellers.

The green pods and young leaves of many leguminous plants are valuable and largely used as vegetables.

The number of leguminous grains which are used as food is considerable, and the above table gives analyses of only a few typical examples. Mung gram may be taken as an average representative of the various kinds of gram and dhal in ordinary use. Pulses rarely contain less than 20 per cent. of albumenoid, peas sometimes contain 28 per cent., and soy beans more than 35 per cent. A good Madras sample of Tur dhal, analysed by the author, contained over 25 per cent.

The ground-nut is remarkable for the large quantity of oil which it contains. It is commonly prepared as food by being roasted and husked.

The soy bean is largely used in China and is cultivated in India and Upper Burma. It is the best of all pulses for supplementing the deficiencies of rice and other starchy cereals because of its great richness in albumenoids, oil and mineral matter.*

Animal Foods.

Animal albuminous foods are the most easily digestible and, in most countries, the most extensively used of substances rich in albuminous material. The flesh of various animals, including fish, is eaten by Europeans, Mahometans and the majority of Hindus when they can get it. Flesh-eating Hindus are by their religion precluded from eating beef; while, for the same reason, Mahometans may not eat pork. Brahmins and other caste Hindus, who may not eat any flesh, are, however, very partial to milk, in its natural state, or in the form of curds (*tyre*) or butter-milk and

* Church.

ghi, as an article of diet, and many so-called vegetarians eat eggs.

The percentage composition of the most important animal albuminous foods is shown in the following table * :—

——	Albu-menoid.	Oil.	Sugar.	Water.	Salts.
Lean meat	18·3	4·9	...	72·0	4·8
Fish	16·0	5·0	...	78·0	1·0
Eggs	14·0	10·5	...	74·0	1·5
Milk	4·8	3·3	4·2	87·0	0·8
Blood	21·2	0·3	...	77·9	0·6

In the above analyses the meat is without bone or fat and the eggs are without shell.

Dried fish and dried meat contain nearly 50 per cent. more albumenoid constituents than the same articles when fresh.

Meat is commonly prepared for food by being cut into pieces about an inch in diameter, which are (1) mixed with curry stuff and fried in fat, oil, or ghi; (2) spitted together, smeared with condiments and fried or roasted as *kabab;* (3) boiled or stewed along with vegetable curry. Europeans generally roast or boil meat in large pieces. Meat loses about 20 per cent. in weight by boiling and 30 per cent. by roasting. The proportion of bone and fat in meat varies much with the kind and condition of the animal and in different parts of the same animal. In average Indian mutton bone forms about 25 per cent. of the whole carcase and fat less than 15 per cent.

Fish is generally a wholesome and nutritious food, being nearly equal in value to lean meat. Fish, whether fresh, salted or dried, is a favourite ingredient of curries. It is deficient in mineral constituents. Some kinds of fish †

* Meat—lean mutton—Letheby.
Milk of Bengali cows—Macnamara.
Blood—Becquerel.

† Intestinal irritation and collapse, and sometimes delirium are caused by poisonous fish. The poisonous nature of the globe-fish is well known, and the occasional poisonous effect of oysters. *Dr. Day* mentions a barbel and a carp found in Himalayan streams which are poisonous. The Indian mackerel (*Scomber*) and sardine (*clupea*), both abundant on the Malabar coast, are sometimes poisonous, especially when beginning to decay. Fish may become more or less poisonous from being kept in very foul tanks.

are always and other kinds are occasionally poisonous. *Crustacea,* such as prawns, and *mollusca,* such as oysters, resemble fish in nutritive value, but contain less oil.

Eggs of the common fowl, or of other birds, form a completely digestible food, which is, weight for weight, nearly equal to lean meat in albumenoid and superior to it in oil. Eggs are often eaten hard boiled and cut up in curries ; but they are more easily digested if the white and yolk be mixed together and boiled (poached) or fried in ghi or oil to form an omlette which may be cut up and curried. Eggs differ a good deal in size; an average Indian hen-egg (deducting shell) weighs about $1\frac{1}{4}$ ounce.

Milk is an important food in all countries, but in India it is especially so, as it forms the sole animal food of Brahmins and some other classes and is more or less partaken of by all. The quantity of milk yielded by cows varies considerably with the breed and food of the cow and the age of her calf; Indian cows do not often yield more than $4\frac{1}{2}$ pints in a day. The composition of cow's milk is tolerably uniform except with regard to cream (oil) which varies considerably (1·9 to 4 per cent. or more). Milk is rarely taken raw, except by Europeans; boiled milk is preferable because it keeps better, and any germs which may be present are destroyed by boiling.

The milk of animals for some days after calving is of a very oily nature and likely to cause diarrhœa.

Tyre is milk boiled down, some water being thus evaporated, and coagulated by the addition of an acid (which causes the *casein* to solidify). It may be reckoned as a little superior to ordinary milk in nutritive value.

Cream is the most oily portion of the milk, which separates and rises to the top after milk has been kept for some hours. Its separation is hastened by adding a little hot water to milk.

Butter is the oil of milk, separated from milk or cream by churning, and containing a variable amount of *casein* (the albumenoid of milk) and water. A little salt is usually added to make it keep better.

Ghi is melted purified butter, and if pure and fresh, is an easily digested kind of oil.

Butter-milk is the milk which remains after the separation of butter. As sold it is acid, more or less coagulated,

and mixed with a variable quantity of water which is added to hasten the separation of butter, but should not exceed one-fourth part. Unwatered butter-milk is equal in value to milk, less the oil, of which it retains very little.

Blood is a very valuable and easily digested food, which is often partly or wholly wasted when animals are slaughtered. It is the practice to drain off as much blood as possible from a carcase, but it ought all to be carefully saved. It may be cooked by being mixed with condiments and fried in ghi or oil, or it may be mixed with milk or with eggs or with the flour of any grain and be fried or otherwise cooked.

Oily Foods.

Oils may be divided into animal and vegetable, the former being the more readily digestible. Solid animal oils are commonly termed fats. Ghi is the most familiar example of an animal oil in this country. Fat is found in all animals on the inside of the loins and under the skin, as well as in other parts. The liver of fish contains a large amount of oil. Pork contains much more fat than any other kind of meat.

Vegetable oils are expressed from various seeds: ground-nut, coconut, and gingelly oils, and kokam-butter are the vegetable oils which are most used as food. Ghi and melted purified fat consist entirely of oil. Butter contains about 81 per cent. of oil, 4 of casein, 2·5 of salt, and 12·5 of water. Crude fat is very similar in value.

Starches and Sugars.

The principal starches are the different kinds of arrow-root, obtained from several plants, and sago, from the pith of certain palm trees. They consist of starch with about 17 per cent. of water and are almost entirely digestible. Potatoes and yams contain about 20 per cent. of starch.

Sugar of the refined and crystallized kind produced from the juice of the sugar-cane is used only by the wealthier classes. It contains about 5 per cent. of water. Jaggery, which is commonly used, is a less pure sugar obtained by boiling down the juice (toddy) of some palm trees, especially the palmyra and bastard date.

Vegetables and Fruits.

Vegetables and fruits are of much importance in diet, their special value depending not so much upon the amount of nutriment as upon the vegetable acids and salts which they contain and which render them necessary ingredients of a perfect diet. Persons who are deprived of vegetables or fruit, especially if they have been previously accustomed to them, suffer from a diseased condition termed *scurvy*. Vegetables are nearly always eaten cooked and fruits raw, some fruits being used either as fruit or as vegetable.

Vegetables are ordinarily cooked by being (1) boiled with condiments as mulligatawny, (2) used as dry curry boiled and smeared with curry stuff, or (3) fried in ghi or oil and mixed with curry stuff as ordinary curry.

Vegetables and fruits may be divided into four classes; (1) starchy and saccharine, (2) green, (3) watery, and (4) condimentary, all classes being valuable antiscorbutics.

The starchy and saccharine vegetables are usually tuberous or fleshy roots, such as the potato, yam, carrot, onion and radish. These, and fruits of kindred nature, such as the plantain, custard apple, and bier, are of considerable value as foods. The sugarcane, though not a fruit proper, may, for diet purposes, be classed with these fruits.

Some green vegetables are also useful as nutritives, such as the pods of many leguminous plants, brinjal, and bandikai. Cabbage and greens of various kinds are less nutritive and are useful mainly as antiscorbutics. Watery fruits and vegetables, as the various kinds of cucumber, pumpkin and melon, the jack, mango, orange and grape, are good and pleasant antiscorbutics.

Condimentary fruits and vegetables are also useful for the same reason, but are principally employed for flavoring other food. Such are tamarinds, limes, turmeric, and aromatic leaves, fruits, and seeds of various kinds as capsicum, coriander, pepper, omum, &c.

Nuts, such as cashew-nuts, almonds, and walnuts are not very common articles of food, except cocoanut which is generally used as a condiment in curries; but they are rich in albumenoid and in oil, and consequently very valuable as food. They are, however, apt to disagree with those unaccustomed to them and they are indigestible unless well masticated.

Fruits and vegetables, wholesome in themselves, often cause indigestion and diarrhœa, because they are eaten in excessive quantity, or are unripe or overripe or stale; but they are sometimes unwholesome owing to the possession of more or less poisonous properties, for instance wild varieties of the cucumber order.

Beverages.

A consideration of foods would be incomplete without some notice of alcoholic and other liquids which are commonly used as drink. Water, the only essential beverage, is so important that it is treated of in a separate chapter. Other beverages may be classed as; (1) sherbets, (2) alkaloidal drinks, (3) fermented liquors, (4) distilled liquors.

Sherbets are made from the juices of various fruits, such as the lime, orange, grape, or pomegranate, mixed with water, and sometimes with sugar and aromatics added. They are pleasant and wholesome drinks, valuable as antiscorbutics. Cunjee-water and pepper-water may be classed with these beverages.

Tea and *coffee* are the principal alkaloidal drinks, so called because their active constituent is a substance belonging to the class of alkaloids. Tea also contains tannin, to which dyspepsia and constipation are occasionally due if the tea be too strong or too long infused, and coffee contains some oil. These drinks are of no value as nutrients, but they are mild non-intoxicating stimulants. Like other warm drinks their mere warmth has a certain stimulating effect. Coffee is a stimulant to the heart, but tea is said not to be. The effect of both tea and coffee is usually tonic and beneficial, but, if used to excess or in peculiarly excitable temperaments, they may be prejudicial and lead to undue nervous excitement and sleeplessness.

Fermented liquors are produced by the fermentation of sugar or starchy substances mixed with water. *Toddy* and *beer* are the most important of these liquors. Toddy is the juice of various palms, principally the palmyra, bastard date, and coconut. The juice as it flows from the tree consists of water, containing a considerable quantity of sugar and a little albuminous matter in solution; but it soon begins to ferment (owing to the growth of certain microphytes in it), its sugar being converted into alcohol and carbon dioxide gas; the latter is the cause of the

frothing up of fermenting toddy. The fermentation is complete usually within 24 hours. Coconut toddy ferments most rapidly and contains most alcohol, date toddy comes next. Toddy averages about the same strength as rather light beer * and is very similar to it in its effects.

Beer is obtained by fermenting malted grain, usually barley or rice, or grain prepared by being strongly heated by steam. Both beer and toddy contain a small quantity of sugar and albuminous substance, which besides their alcohol, give them some little value as food.

Distilled liquors are obtained by distilling the alcohol (mixed with water) from fermented mixtures of sugar or starchy substances. The peculiar flavors and odors of different kinds of spirit depend upon the presence of minute quantities of various essences derived from the substances used, but alcohol is the principal ingredient of all. Toddy, jaggery, the refuse of sugar factories, mhowa flowers, and grain are the principal substances from which distilled liquors are obtained in this country.†

The strength of ordinary arrack is about 40 per cent. of pure alcohol, by volume (30° under proof).

The effects of alcoholic liquors depend upon the degree of dilution of the spirit with water or food and upon its absolute amount, as well as upon individual peculiarities. A small quantity of alcohol only unites with oxygen in the blood, thus evolving heat or other form of energy and at the same time preventing the consumption of other carbonaceous food by depriving the blood of oxygen.‡ Thus only a small quantity of alcohol can be consumed in the body. A large quantity acts as a poison by causing certain injurious changes in the blood and by its effect upon the nervous centres. The largest quantity of alcohol which can be daily consumed without obvious injury was found experimentally by Parkes to be 2 ounces. The injurious reaction which follows alcoholic stimulation appears to be due to dilatation (from partial paralysis of their nerves) of the blood vessels after the primary stimulant effect upon the heart

---

* Average strength, stated as *proof spirit* per cent. (proof spirit is nearly half pure alcohol): coconut toddy 11·9, date 10·9, brab 8·2. *Lyon. Rep. Chem. A., Bombay*, 1883.

† Cashew-nut fruit is used on the Malabar coast, and sorghum cane and prickly-pear fruit have been used in other places.

‡ Dujardin-Beaumetz, 1886.

has ceased. Many diseases of the nervous centres and of the liver, stomach, kidneys, and blood vessels have been traced to the habitual abuse of alcohol; while, on the other hand, no real benefit, either in hot or cold climates, can be attributed to its use, even in moderation, unless in cases when food is deficient or when the alcohol is employed as a medicine. The drinking of arrack or other spirit, without food, is the most pernicious form of intemperance; and from the author's experience for some years at the General Hospital he believes that this form of intemperance is the cause of much disease, mortality, and misery in Madras, and that it is unhappily increasing year by year. Alcoholic drinks at best must be regarded as unnecessary luxuries and dangerous ones, because excess is not easily avoided.

Parkes, referring to the issue of spirit rations to troops, considered that "if spirits neither give strength to the body, nor sustain it against disease . . . . . then the medical officer will not be justified in sanctioning their issue under any circumstances."

Rations and Dietaries.

If the principles and facts already laid down be borne in mind there will be little difficulty in constructing rations suitable for any given circumstances or in detecting any deficiencies of existing rations; but this subject is one regarding which ignorance has so often resulted in wide-spread mortality that, even with some repetition, a separate section is here devoted to it.

The question of diet is so frequently connected with that of disease and mortality, that in any case where excessive sickness and mortality—especially if due to bowel diseases, scurvy or anæmia—is found to prevail among a population or in bodies of troops, or in jails or hospitals, the first suspicion of an experienced sanitary investigator is directed to diet.*

The constitution of one ounce of each of the principal food substances is shown in the following table in fractions of an ounce. It may be observed that this table is merely a repetition of the separate tables already given, with the decimal points of the numbers moved two places to the left

* The following figures are given by Ewart to exemplify the influence of diet on mortality: deaths per 1,000 of strength of prisoners from

so as to indicate fractions of unity instead of percentages. It will, however, be found of great utility in facilitating the construction of dietaries to have all the figures in one conspectus.

Table for calculating diets.

Food Stuffs.	Albumenoid.	Starch or Sugar.	Oil.	Mineral.	Fibre.	Water.
Cereal grains.						
Rice	0·065	0·791	0·006	0·006	0·014	0·128
Koda	0·070	0·712	0·021	0·013	0·007	0·117
Ragi	0·073	0·732	0·015	0·023	0·025	0·132
Gundli	0·091	0·690	0·036	0·035	0·046	0·102
Maize	0·095	0·707	0·036	0·017	0·020	0·125
Joar	0·093	0·723	0·020	0·017	0·022	0·125
Bajra	0·104	0·715	0·033	0·020	0·015	0·113
Kagni	0·108	0·734	0·029	0·012	0·015	0·102
China	0·126	0·694	0·036	0·014	0·010	0·120
Wheat	0·135	0·684	0·012	0·017	0·027	0·125
Amaranth	0·137	0·584	0·060	0·052	0·048	0·119
Leguminous Grains.						
Chick-pea	0·217	0·590	0·042	0·026	0·016	0·115
Mung gram	0·227	0·558	0·022	0·044	0·048	0·101
Pea	0·236	0·575	0·015	0·025	0·010	0·118
Lentil	0·249	0·595	0·013	0·022	0·012	0·118
Ground-nut	0·245	0·117	0·500	0·018	0·045	0·075
Soy bean	0·353	0·260	0·189	0·046	0·042	0·110
Animal Foods.						
Lean meat	0·183	...	0·049	0·048	...	0·720
Fish	0·160	...	0·050	0·010	...	0·780
Eggs	0·140	...	0·105	0·015	...	0·740
Milk	0·048	0·042	0·033	0·008	...	0·870
Blood	0·212	...	0·003	0·006	...	0·779
Starches and Sugars.						
Arrow-root	...	0·83	...	...	...	0·17
Sugar	...	0·945	...	0·005	...	0·050
Oils and fats.						
Butter	0·040	...	0·810	0·025	...	0·125
Ghi and oil	...	..	1·000	...	...	...
Vegetables and Fruits.						
Starchy and saccharine (potato or plantain) ..	0·025	0·211	0·001	0·013	0·010	0·740
Green and watery (cabbage)	0·002	0·058	0·005	0·007	0·018	0·910

---

diarrhœa and dysentery alone under old and deficient prison dietaries compared with deaths per 1,000 among comparatively well-fed sepoys:—

Any ordinary rations can be easily and quickly reduced to their alimentary constituents by means of the above table: all that need be done is to multiply the quantity in ounces of each food-stuff contained in the ration by the numbers given opposite it in the table in order to obtain the quantity in ounces of its alimentary constituents. For example, the lowest Famine Code diet consists of 2 oz. of dhal and 20 oz. of cereal grain. If we suppose Bengal gram (chick-pea) and cholam (joar) to be used, we multiply each of the numbers opposite chick-pea in the table by 2 to obtain the quantities of albumenoid, &c., in 2 oz. of it, and similarly we multiply the numbers opposite joar by 20 to obtain the quantities in 20 oz. of it. This gives:

——	Albumenoid.	Starch.	Oil.	Mineral.
2 oz. Bengal gram ...	0·434	1·180	0·084	0·052
20 oz. cholam ...	1·860	14·460	0·400	0·340
Total value of ration...	2·294	15·640	0·484	0·392

Now to ascertain the ratio of nitrogenous (albumenoid) to carbonaceous constituent in this ration we obtain the starch equivalent of the oil by multiplying the latter by 2·4 ($0·484 \times 2·4 = 1·16$); this being added to the amount of starch

——	Bengal.	Madras.	Bombay.
Prisoners	21·65	16·99	15·07
Sepoys	1·63	2·10	2·09

Sickness and mortality in the Bombay House of Correction.

	Hospital admissions.	Deaths per 1,000 per annum.
Old bad diet	1,761	64·5
New improved diet	818	11·4

In another jail when the food was reduced from 45 oz. to 27½ oz. per diem, the mortality rose from 42·4 to 117·5 per 1,000. In this case the proportion of nitrogenous nutriment to carbonaceous was only 1 to 10.

The above instances are sufficient for the present purpose, but it may be mentioned that more recent examples could be given from the Madras Presidency.

gives 16·8 as the total weight of carbonaceous constituents, reckoned as starch. Dividing the weight of albumenoid into this $(\frac{16 \cdot 8}{2 \cdot 294})$ gives 7·2; the proportion of nitrogenous to carbonaceous constituent in this diet is therefore 1 : 7·2, which is too low. The starch equivalent of the oil we have seen is 1·16 and the proportion $(\frac{16 \cdot 8}{1 \cdot 16})$ which it bears to the total carbonaceous constituents is 1 : 14·5, this also being much too low. This ration is therefore very (though perhaps unavoidably) imperfect as it stands. Its defects might be corrected by (1) the addition of a little animal food rich in oil, or (2) of seeds rich in albumenoid and oil, such as ground-nuts or soy beans, or (3) by increasing the proportion of gram to cereal grain and adding the requisite amount of oil separately. Nearly ½ oz. of salt and some fresh vegetables would also be required.

In constructing rations for any given individual or group, the simplest plan is, in the first place, to determine the proportions of constituents and the absolute quantity of food required according to the circumstances of the case; secondly, to take a quantity of the staple food-stuff equal to the amount of food required; and, thirdly, having reduced this to its constituents, to substitute for a part of it such portions of available secondary foods as may be needful to give the proper ratios of constituents.

Cases sometimes occur in which only a few food-stuffs are available—possibly only one; and in such cases it may be impossible to apportion the constituents in due ratio. The only principle which can then be observed is to make sure that the food shall contain at least a sufficiency of albumenoid nutriment, even if other constituents have to be in great excess.

The question of expense is usually an important one in the formation of dietaries, and one which has to be carefully considered; it cannot here be entered into further than to state that it usually resolves itself into the substitution of the cheaper for the more expensive secondary foods and the limitation of variety in the diet.

To sum up, all the points which require attention when constructing dietaries are: available food materials, their composition and their cost; amount of food required, having regard to body weight, age, work, habit, and climate; proportions of alimentary constituents required, having

regard to the same considerations; provision of fresh vegetables or fruit; provision of salt; variety; cookery; digestibility; allowance for waste; division of ration and hours of meals; arrangement of rations for groups of individuals. Sufficient has already been said regarding some of these points; those which have not been, or have been but partly, discussed must now receive attention.

Fresh vegetables and fruits are necessary, in all good dietaries, to prevent scurvy. They are also useful in giving variety of flavor and consistence to the staple articles of food and in promoting regular action of the bowels. If ordinary vegetables cannot be obtained, the leaves of any non-poisonous plants may be eaten as substitutes. Lime-juice is a good antiscorbutic; it is usually preserved by the addition of some spirit and is always carried in ships for use when fresh vegetables are not available. Dried fruits and vegetables may also be used with advantage when fresh are not procurable. 4 to 8 oz. per day is a moderate allowance of vegetables or fruit, though less may suffice for the preservation of health. Unless vegetables or fruit are used in larger quantities than this their diet value may be disregarded in calculating rations and serve as a sufficient allowance for waste.

The quantity of *common salt* to be added to a ration will depend upon the nature as well as the absolute amount of the food materials; for instance, salt fish or meat may require no such addition, while cereal grains and vegetables require most. Enough should always be used to make up, along with the *ash* in the food-stuffs, a sufficient amount of mineral food. The necessary quantity rarely exceeds half an ounce.

Other mineral salts are necessary, especially phosphates of potassium and calcium, and their place cannot be taken by common salt. It is, therefore, improper to supply the mineral deficiencies of such food-stuffs as rice or sago by the addition of common salt only. When rice, or other food deficient in mineral matter, is the staple, it would be very desirable to adopt a practice which is said to be followed by some rice-eaters in Bengal, who use the ashes of gram plants along with their food. Any kind of gram or bean plant is well suited for the purpose, as such plants contain a large proportion of phosphoric acid. Habitual rice-eaters should employ the ashes of these plants, or of

other green plants, mixed in the proportion of at least one-third with the common salt which they use as a condiment.

Variety in diet is an important consideration. Even when only one principal staple food is eaten, great variety of consistence may be obtained by different modes of cooking it, and variety of flavor by the use of various secondary foods and condiments. Thus even the poorest usually obtain considerable variety in their food. Indigestion and malnutrition are apt to result from a monotonous diet; and, in arranging dietaries, it should always be a practice to vary the food as much as possible. As a rule, it is not difficult to make some change for every day in a week.

Cookery is another subject which should engage attention. Good food is often rendered distasteful by bad cookery, while indifferent food is often made palatable by good cookery. Palatability is a very important matter; it is a familiar fact that savory and well-cooked food "makes the mouth water," that is, it excites the flow of saliva and probably at the same time of gastric secretions, and therefore such food is readily digested as well as agreeable to eat. On the other hand unsavory and ill-cooked food is apt to excite disgust, nausea, and indigestion, or it may even be rejected by the stomach. Cookery is, to a great extent, a matter of taste and of habit, and varies among different races and classes; therefore, no very precise general rules regarding it can be laid down, except that it is better that most food substances should be too much rather than too little cooked; grains, especially leguminous grains, are thus rendered more digestible, and any parasites or germs which may be present in other articles of food are more surely destroyed. The most ordinary methods of cooking have been mentioned under the different classes of food-stuffs.

Regarding *digestibility* it should be noted that a fair proportion of indigestible material is desirable in food, in order that absorption of nutritive materials and intestinal action may be promoted by its bulkiness. A diet which consists almost wholly of digestible materials is apt to produce constipation and possibly contraction of the alimentary canal. Unusual or badly-cooked articles of diet, though nutritious in themselves, may, on the other hand, prove to be too indigestible.

Some allowance must always be made for *waste* in preparing food and for a portion of it which remains

undigested. 5 per cent. excess of alimentary constituents may be allowed on this account,* or, as previously suggested, the nutritive value of the vegetables in the diet should not be reckoned.

The *hours* and *number of meals* in a day and the division of the food between them are, to a great extent, matters of habit. Young children should have food at more frequent intervals than adults. Three meals a day is the usual number for adults in India (and in most other countries). A working man will ordinarily eat a light breakfast at 6 A.M., say $\frac{3}{4}$ lb. of porridge with salt and condiments and cunjee-water, or perhaps butter-milk or a little tyre; at 1 P.M., dinner, a similar meal, with possibly a little curry; and at 8 P.M., supper, the principal meal of the day, consisting of about $1\frac{1}{2}$ lb. of porridge, pudding, or boiled grain, with some vegetable curry containing ghi or oil and fresh vegetables or gram or dhal, and occasionally fish or other meat.

Rations for large numbers.

The construction of rations for single individuals or for families is not a difficult matter, but when large numbers of people, differing in weight, if not in age and habits, have to be fed, the subject becomes much more complex. We have seen that young children require a proportion of alimentary constituents and an absolute quantity of food relative to weight different from what is needed by adults. It is always necessary therefore to provide a separate diet for young children. Those over fourteen years of age may be treated as adults. With regard to the apportionment of diet according to weight, in an assemblage of adults, it is a prevalent practice to regulate the diet on the basis of the *average* weight of all the individuals. It follows that those who are above the average weight receive too little, while those who are below it receive too much food: in other words, about one-half of the people are under-fed and the other half over-fed. This method is therefore obviously not correct. If all the individuals of a group are to be sufficiently fed, the diet must be calculated for the weight of the *heaviest*. Thus considerable waste, or overfeeding of the majority, cannot be avoided in laying down a sufficient

* Church.

uniform ration for a large number of individuals. The waste or over-feeding may, however, be reduced to small limits by dividing the persons into classes, according to weight, and giving a ration to each class based upon the greatest weight in that class. In weighing individuals for this purpose, excessive fat should not be reckoned, and judgment must be used in relegating adipose individuals to a lower class than their mere weight would accord them.

Finally, it may be stated that absolute accuracy is practically unattainable in constructing dietaries; but a near approximation to requirements can nearly always be made, and it should be a rule to err by excess rather than by deficiency.

Preservation of Food.

Preserved foods should generally be avoided when fresh foods are obtainable. Many perishable food-stuffs may be preserved by drying, by exclusion of air, or by the addition of salt, sugar, oil, vinegar, or certain chemicals. Fish is commonly preserved by salting and drying, and meat sometimes in the same way; both are occasionally sun-dried without salting. Some fruits may also be preserved by drying, but they are more frequently preserved in sugar. Vegetables are rarely dried but often pickled in vinegar or oil. Among chemicals which are used for preserving food may be mentioned boracic acid, a harmless material, which has considerable power in preserving fish and meat. It may also be employed to preserve milk for a short time. A common and very perfect way of preserving all kinds of food substances is to solder them up while hot in tinned cans. The heat destroys all germs in the substance and air (containing germs of microphytes which cause decomposition) being excluded, such substances may be kept for an indefinite time.

Unwholesome Food.

Articles of food, wholesome and nutritious in themselves, may be unwholesome for those who are unaccustomed to them, and, at first, cause indigestion and diarrhœa. Thus wheaten cakes or dhal often disagree with those who are not used to them. Again individual peculiarities occasionally occur: there are persons who cannot eat certain ordinarily wholesome substances, such as milk or fish, without suffering from colic or from nettle-rash.

The poisonous nature of some fishes and some leguminous grains have already been alluded to. It is probable that the flesh and milk of animals fed on garbage are also unwholesome.

Wholesome food may become unwholesome, or even actively poisonous, by decomposition. Thus mouldy grain or other food, or fruits, vegetables, and more especially animal foods, including milk, which have begun to decay are dangerous to eat.* Instances sometimes occur of fatal poisoning by such articles of food; the author has met with a considerable number of such cases, a few of which may be here mentioned: (1) stale coconut marc, six days' old, caused poisonous symptoms in seven persons who ate it, and four of them died; (2) boiled peas, which were probably also stale, caused illness in twelve persons, two of whom died; (3) fried blood, some of which had been kept for a whole week before cooking, caused poisoning of twenty-five persons, five of whom died.† Colic, diarrhœa, vomiting, and collapse are the ordinary effects produced by decomposed food.

It is a common practice, among the poorer classes, in order to save the expense of a fire, to eat at breakfast, and perhaps also at midday, food which has been cooked on the previous day. Moist substances, such as boiled grain, porridge, tyre, and cunjee-water may become unwholesome when thus kept, and communicable diseases may be propagated by them. Whenever food has to be so retained, it should be covered over and placed in a dry and clean place.

Uncooked or insufficiently cooked food is sometimes dangerously unwholesome. For instance, under-cooked dhal and grain of all kinds is very indigestible. Sweetmeats containing raw rice ought not to be eaten. The consumption of raw grain in large quantity may even cause death.

Foods preserved in tins occasionally become poisonous, though rarely to a grave extent, from the presence of lead or of tin. Copper, derived from the still, is commonly found in arrack,‡ occasionally in injurious amount. Copper poisoning not unfrequently results from cooking acid substances in copper utensils. Lead poisoning occurs occa-

* Not only man but other animals may be poisoned by mouldy food. Sir C. Cameron has published cases of both.

† Rept., Chem. Ex., 1884–86.

‡ Author: Chem. Ex. Rept., 1884, &c.

sionally owing to cooking pots being coated with that metal instead of tin. Lead poisoning has recently occurred in England among persons who used wheaten flour which had been ground in a mill in which a lead elevator was employed. It is not advisable that either copper or leaden vessels should be used in the preparation of food.

Several parasites may be communicated by food. Intestinal round and thread worms are sometimes acquired by swallowing their eggs with raw vegetables. Tape-worm is acquired by eating undercooked meat containing its immature form (cysticercus); and *trichinæ,* and certain other parasites may also be conveyed to man in the flesh of animals infested by them.

Some microphytic diseases of animals, such as anthrax, may be communicated to man in a similar way.* Hence meat, if at all suspected, should be very thoroughly cooked if it has to be used as food.

Adulteration of Food.

Manufactured or prepared foods are often adulterated. Some substances used as adulterants are injurious to health, and some may be offensive on other grounds, but all must be condemned as fraudulent. Some of the most common adulterations may be mentioned.

Milk, butter-milk and tyre, are commonly adulterated with water—often very dirty water, which may convey the germs of disease. Flour, plantains, and other substances have been employed to thicken milk thus adulterated. What is sold as butter-milk often consists of little but water, and this is occasionally thickened with the juice of a plant (*Urœmia speciosa*).

Ghi is frequently adulterated with ground-nut and gingelly oils, and sometimes with animal oil. Some samples of ghi having been found adulterated with animal fat led to

* There is much evidence that *tuberculosis* may be transmitted thus and possibly through milk. This disease is common in cattle, especially when stall-fed, but it is chronic and not very fatal in the cow, therefore often overlooked. *Toussaint* gave it to pigs, by feeding them on *juice* of diseased meat. This disease has lately (1888) been included in the French Contagious Diseases of Animals Act. It appears to be less common in India than in Europe; but accurate statistics are wanting.

the passing of a special legal enactment in 1886,* and 37 out of 71 samples of ghi examined in Calcutta were found to be adulterated. In Madras ground-nut oil appears to be the most common adulterant of ghi.

Butter is adulterated most commonly with water and with fat. As much as 25 per cent. of water can be mixed with butter, and about this amount was found by the author in some samples supplied by a contractor to a public institution.

Grains and spices are nearly always purchased whole by the consumer in India, and are therefore not liable to adulteration, except with sand and dirt.

So-called foreign liquors are sometimes entirely fictitious and made up with common arrack variously flavored and colored.

Inspection of Food.

An organized inspection is manifestly important to check the sale of unwholesome or adulterated articles and the spread of disease by means of food. A competent food-inspector must be familiar not only with the appearance, odor and other qualities of good food-stuffs, but he must know how to detect bad ones and be guided by definite principles in condemning any article as unfit for food. A food-inspector, or even a medical officer, cannot be expected to perform a chemical analysis of foods—inspected articles must therefore be sometimes forwarded to a competent analyst for regular examination—but medical officers are occasionally able to make a useful microscopic examination of certain articles and to apply some qualitative tests. The most noteworthy points regarding food inspection and the examination of ordinary food-stuffs are here to be noticed.

In the inspection † of bazaars, markets, bake-houses, dairies, cattle pens and sheds, and slaughter-houses, the general cleanliness, provision of a pure water-supply, proper

---

* Bengal Act III of 1886.

† Inspections of this kind should be systematically provided for in bye-laws framed by local authorities under the provisions of Madras Municipal District Municipalities or Local Boards Acts. The "Model Bye-laws for Sanitary Authorities" issued by the English Local Government Board may be referred to. See also Mr. Jones' Manual, pp. 73, 74. Markets and slaughter-houses should be the property of the Local Authority.

drainage and ventilation, regular conservancy, absence of foul or badly-made drains, latrines, dung-hills, or other causes of contamination of air, water, or soil, absence of disease among milch cows and among animals intended for slaughter, absence of infectious diseases among sellers and preparers of food or their servants or families, finally, wholesomeness and purity of all articles of food exposed for sale, are the main points which should engage attention.

Grain of all kinds is liable to become mouldy, therefore more or less poisonous and unfit for food, if kept in a damp place. Mould may be recognized by discoloration of the grain, the alteration of color being variable and depending on the kind of mould, by the presence of a peculiar musty odor, and, if the mouldiness be far advanced, by the adhesion of grains to one another in lumps. If the mouldiness be only beginning, spots of discoloration may merely be found on separate grains, or entire grains may be so affected. It occasionally happens that certain kinds of mould (as *smut* and *ergot*) attack grain while it is still growing. Mouldy grain should be condemned as food.

Grain which is stored in a damp place may sometimes germinate, or begin to grow, as evidenced by swelling of the seed and cracking or bursting of its outer envelopes, and perhaps partial protrusion of the embryo plant. Such grain should also be condemned as food.

Weevils or other small beetles, sometimes attack corn and eat out the interior of the grains. A close examination of the grain will show the presence of powdery material mixed with it, and hollow seeds will be found which have been perforated by the insects. When the weevils are abundant there is little difficulty in discovering some of them. If a handful of the grain be thrown into water, the hollow grains and weevils will float on the surface. *Acari* are minute arachnids which attack grain in the same way. They may be seen by the assistance of a microscope and closely resemble the *acari* which cause itch. If very numerous, their presence is made evident by fine powdery substance mixed with the grain and hollow or partly eaten grains. Grain which contains only a few weevils or acari may be used at once, but if much infested by such insects it should be condemned.

New rice is unwholesome and may be recognised by the greater opacity and softness of the grains and by its

cooking more rapidly and yielding a thicker cunjee than old rice. New rice cannot be condemned as food, but its use ought to be discouraged.

Flour of wheat or other grains may be attacked by mould or insects in the same way as the entire corn. It should not have an unusual color, or a mouldy or acid smell or taste, nor contain any lumps. Flour is liable to adulteration with the flour of other grains and with mineral substances. Wheaten flour when kneaded into a thick paste with water should be very tenaceous and stringy. The admixture of the flour of various grains may readily be detected by the microscope, owing to the different appearances of the starch granules and coats of the seeds in each kind of grain.* Mineral adulterations, if in any quantity, may be detected by shaking up a pinch of the flour in a small bottle with some chloroform, and allowing it to stand for some time: the flour, if pure, will all float on the chloroform.

Bread may be heavy and indigestible from bad toddy or other leaven, from the oven not being sufficiently hot, or from too much water having been used. The water should never exceed 45 per cent. and the bread should have no acid taste. Bread containing too much water soon becomes mouldy, and, like all mouldy food, must then be rejected. Bread adulterated with the flour of rice, &c., is less tenaceous than pure wheaten bread. Bread made with mouldy flour is of a peculiar color and ought not to be used as food; a mould † was found in a specimen of dark-blue bread examined by the author. Bakers sometimes add alum and more rarely copper sulphate to improve the whiteness and keeping qualities of bread made with bad materials. The latter is a particularly dangerous adulteration. Any medical officer may detect these adulterations by the following tests. Some of the bread having been burnt until only white ash remains, this ash is treated with a small quantity of solution of ammonia: if the liquid becomes blue, copper is present. A little tincture of logwood having been mixed with an equal quantity of a solution of ammonium carbonate, a crumb of the bread is placed in the mixture for a few minutes and gently dried: if alum be present it becomes bluish when dry, if otherwise brown.

---

* See plate of starches.

† Probably *Ascophora nigricans.*

In *vegetables and fruits,* discoloration and softening in patches or throughout are the well-known signs of decay, and all decaying vegetables and fruits should be rejected without hesitation. Over-ripe or unripe fruits should not, as a rule, be used as food.

Milk, butter-milk, and to a less degree tyre, are very liable to be adulterated with water. Flour or other substance may also be dishonestly added. Any sediment which is found in milk should be subjected to microscopic examination; it may consist of impurities in added water, or of flour of some grain (which can be identified by its starch granules), or of blood, &c., from a diseased cow. The presence of added water in any quantity may be determined most readily by obtaining the specific gravity of the milk by means of a special instrument (hydrometer), or a urinometer, such as may be found in every hospital and dispensary, will answer the purpose. The specific gravity of milk ranges from 1035 down to 1026; if below the latter figure the milk should be condemned as watered. The specific gravity of milk is increased, by about 2, by skimming off the cream, and it is lowered, by about 3, for every 10 per cent. of water added. In testing the purity of milk, it may therefore sometimes be desirable to determine the percentage of cream as well as the specific gravity. This may be done by using a long glass tube or jar, graduated into 50 equal parts; having filled it with the milk to the top mark, the cream which floats on the surface after four hours' standing should occupy at least 3 divisions (= 6 per cent.).

The specific gravity of curdled milk, tyre, or butter-milk may be easily determined by liquifying it by means of a solution of caustic alkali (potash or soda) of known specific gravity and taking the specific gravity of the mixture. For instance if the specific gravity of the alkali solution be 1020 and the specific gravity of a mixture of equal parts of this and tyre be 1025, it is evident that the specific gravity of the tyre must be 1030.*

Milk easily becomes tainted by foul effluvia, and moulds and disease germs readily live and multiply in it. Hence it is important that dairies, cows, and milkmen should be subject to inspection.

---

* This test, devised by the author, is included in the ready tests for ascertaining the purity of milk, butter-milk, and tyre supplied to jails, contained in a Medical Department Circular, 1884.

Meat may be unfit for food because it is decomposing or is diseased. A food-inspector should be well acquainted with the appearance of healthy animals, alive and dead. No beast which presents appearances of disease should be slaughtered for food; but animals injured by accident may be eaten as a rule. "The animal's coat should be in good condition, the skin supple and free from scabs, pustules, or sores of any kind. The animal itself should be free from any discharge, and its breath from any offensive odor, while the breathing should be easy and noiseless. Its eyes should be bright, and it should give no signs of shivering or being in pain."* Lameness due to footsoreness, when animals have been driven far to market, is of no consequence.

Good meat should be neither too pale nor too dark colored—lamb, veal, and pork are naturally paler than beef and mutton; it should be firm to the touch, and little or no fluid should exude from it; it should have an acid reaction (redden blue litmus); the fat and the marrow of the bones should be free from small clots or infiltrations of blood; the odor should be faint and not unpleasant; meat should not crackle on being pressed: this indicates the presence of air or gas, which may be due to decomposition or to a dishonest and reprehensible practice of some butchers who blow air into meat to make it appear more plump.

Decomposing meat acquires an increasingly disagreeable odor, becomes soft and inelastic, and changes color first to a paler hue and later to livid and greenish.

Diseased meat is sometimes soft and flabby, with a juice which may be not acid; it may be too pale in color or else too dark and full of blood; the fat and marrow may be discolored, and present clots or infiltrations of blood; the odor may be unpleasant; decomposition usually sets in rapidly. The lining membrane of the chest and belly cavities should be examined for signs of inflammation which destroy its natural smooth and glistening appearance; healthy lungs are spongy, float in water, and present no solid patches, nor tubercles, nor abscesses, nor parasites; the spleen should not be enlarged nor softened; the liver should be free from abscesses and parasites.

The parasitic disease called *measles* in the ox and pig is recognised by the presence of small round bodies or

* G. Wilson's *Hand-book of Hygiene.*

bladders, about the size of a grain of cholam, in the flesh or in the liver or lungs of these animals. The little bladders are immature tape-worms; and, if the imperfectly-cooked flesh of animals containing them be eaten, they become developed into tape-worms in the bowels. *Trichina spiralis* is a minute worm which sometimes infests the flesh of the pig and may be communicated to man. Trichinæ can only be seen by the unaided eye as very small specks in the flesh, and a microscope is needed to reveal their true nature.*

Flukes are often found in the liver and other parts of beef and mutton carcases. They are easily destroyed by cooking and are not often communicated to man.

Some kinds of fish, as already mentioned, are always and some others are occasionally poisonous. Parasites are extremely common in all fish. In 1883 a scare was created in Pondicherry, and spread to Madras, by rumours of dangerous parasitic diseases among fish; but, on investigation, no cause was found for the alarm.†

Flukes are especially common in fish. Fish, therefore, as well as other kinds of meat, should always be well cooked.

---

* I find no record of the occurrence of Trichinæ in Indian pigs.

† V. Appendix B to Rep. San. Commr., Madras, 1883, by Deputy Surgeon-General M. C. Furnell. Professor Cobbold, who was referred to, wrote: "All your marine fishes have entozoa, but probably none of these are injurious to man in India." Professor Huxley states that they "are easily killed by cooking."

CHAPTER III.

WATER.

Impurities of Water.

Perfectly pure water is never found in nature. Natural waters always contain in solution some quantity of the gases of air and some solid matter, consisting of common salt and other minerals, and usually traces of organic matter derived from plants or animals. Besides such impurities *in solution*, natural waters always contain more or less impurity *in suspension* ; suspended impurities consist of insoluble mineral matter, such as fine clay, and of organic matter, which may be dead or living. The dead organic matter found suspended in water consists of minute dead plants and animals, or small particles of larger plants and animals, in various stages of decay; the living organic matter consists of living plants and animals, many being extremely minute microscopic organisms, and of their seeds and eggs. Some of the impurities, which may be contained in water, are beneficial, whilst others are noxious.

Among beneficial impurities in water may be mentioned the gases of which air is constituted, especially oxygen. These gases (nitrogen, oxygen, and carbon dioxide) render water sparkling and of pleasant taste. Oxygen and carbon dioxide are proportionately dissolved by water to a larger extent than the nitrogen of air.* Oxygen dissolved in water, besides being necessary to support the life of fish and other aquatic animals, serves a very useful and important purpose in gradually oxidising and destroying the decomposing organic matter which may be dissolved or suspended in the water. Carbon dioxide gas dissolved in water affords nourishment to green aquatic plants in the same way that

* The gases in water should consist of 8 to 10 per cent. of CO_2, 30 to 37 per cent. of O, 63 to 70 per cent. of N, the total amount of gases in a good potable water being from 25 to 50 cubic centimetres in a litre—*Dujardin-Beaumetz.*

in the air it affords nourishment to green terrestrial plants, and it also renders soluble calcium carbonate, magnesium carbonate, and other carbonates which are little or not at all soluble in pure water. For the latter reason an excess of this gas is sometimes detrimental.

A moderate quantity * of calcium (lime) and alkali (mostly common salt) salts in water is not unwholesome and is probably beneficial in cases when the food is deficient in salts.

Water is rendered *hard* by calcium and magnesium salts and carbon dioxide gas, and its hardness depends upon the quantity of these impurities which it contains. Hard water does not easily wet the skin, nor wash off dirt from clothes, and much soap is required to form a lather with it. It is, therefore, even when fit for drinking, bad for washing purposes. It is also, unless the hardness be due to carbon dioxide only, bad for cooking, because vegetables and other food-stuffs cooked in it are tougher than if cooked in soft water. Hard water, of the same kind, is unfitted for steam and most manufacturing uses, and it deposits a crust or *fur* on the interior of boilers.

Water, which has a saltish taste, usually due to common salt, is said to be *brackish*; but water, which is too brackish for drinking may sometimes be fit for cooking.

Among suspended impurities, the presence of live fish, molluscs in moderate quantity, and large water plants, as well as of minute green algæ and diatoms, may be considered generally beneficial and purifying in rivers and shallow tanks, though they may exist in many bad waters. The absence of fish and molluscs in perennial rivers and tanks usually denotes very bad water.

The noxious impurities in drinking water are: (1) dissolved minerals in excessive quantity or of a poisonous nature, such as excessive quantities of calcium and magnesium salts, or even a small quantity of lead; (2) suspended mineral matters, such as clay or sand; (3) dissolved organic matter, which may itself be more or less directly poisonous and which is always dangerous because it affords food for such disease germs as are capable of living in water; and dissolved organic matter nearly always denotes the presence of (4) suspended organic matter, which is by far the most

---

* Not more than 0·05 gram per litre of fixed solids.

dangerous impurity of drinking water. Dead organic matter, if in large quantity, is more or less unwholesome in itself, but it is usually dangerous, even in small quantity, because it increases the probability of contamination with dangerous living organisms, and affords food for those organisms. The most pernicious and deadly of all the impurities of drinking water are some of the minute living organisms which it may contain—microphytes or parasites which cause disease in man. All natural waters contain microphytes or their germs, but the best waters generally contain fewest. The great majority of such microphytes are not directly injurious to man, but some of them are the active causes of disease. A water, in which they are likely to live and multiply, must, therefore, always be regarded as suspicious. Not only microphytes themselves but their seeds live much longer in impure than in pure water.*

The eggs or immature forms of various parasites may also be contained in polluted water and thence gain entrance into the human body where they become developed.

Diseases due to Impure Water.

The principal physiological diseases which have been traced to impure drinking water, are diarrhœa and possibly dysentery, from mineral impurities, such as magnesium or sodium salts or suspended clay, or from dissolved organic matter; constipation, from excess of calcium or iron salts; stone in the bladder from excess of calcium and magnesium salts (?); bronchocele attributed to the same cause; lead poisoning produced by small quantities of lead salts and causing dyspepsia, colic, and paralysis. A general low state of health, with occasional bowel derangement and attacks of continued fever, appears to result from the habitual drinking of water polluted with decomposing animal matter.

---

* In some experiments of Dr. Percy Frankland it was found that Koch's cholera spirillum died in pure water in less than nine days, while it had greatly multiplied in London sewage twenty-nine days after its introduction. The same observer (*Jour. Chem. Ind.*, 1887) found that several other specific microbes which remained unchanged in pure water for a considerable time rapidly multiplied in sewage. Dr. Meade Bolton found that the anthrax bacillus soon died in good water, although it may live for three months in polluted well water; but the spores (seeds) of this microphyte have much greater vitality, living in distilled water for three months and in polluted water for nearly a year.

The principal microphytic diseases, which are communicable by water are cholera, enteric fever, epidemic diarrhœa and dysentery, malarious fevers, and perhaps some forms of sore throat and other diseases.

The principal parasitic diseases communicable by water are round worms, thread worms, duodenal worms, flukes, blood filariæ, hydatids, guinea worm.

Besides the danger of communicating specific diseases, the habitual use of polluted water may produce a general impairment of health and increased liability to disease of all kinds.

Sources of Water.

Rain is the origin of all fresh water, except that obtained by distillation from salt water. By *rain water*, however, is usually understood only water which is obtained by the direct collection of rain on house-tops or other prepared surfaces. The rain which falls on the ground partly evaporates, partly flows over the surface, and partly sinks into the soil. The amount which evaporates depends on the temperature, dryness, and movement of the air, and rate and quantity of rainfall; the amount which flows over the surface or sinks into the soil depends upon the inclination of the surface and the nature and dryness of the soil, as well as upon the rate and quantity of rainfall. The water, which flows over the surface and in surface channels, carries all kinds of impurities with it into the tanks, shallow wells, and rivers, in which it finds storage or outlet, while that which sinks into the ground dissolves whatever soluble substances it may meet within the soil, and, if sufficient in quantity, penetrates downwards until it meets with rock or impermeable clay, on the surface of which it flows slowly through the interstices of the porous soil, and forms the usual supply of wells. The height of this subsoil water or ground water, as it is called, is shown by the level of water standing in ordinary wells; there may sometimes be none, and it may vary greatly at different seasons of the year and in different places. It is affected by the level of the water in neighbouring tanks and rivers. Its rate of flow depends upon the inclination of the impermeable layer over which it flows and upon the porosity of the permeable soil through the pores and crevices of which it has to pass. Subsoil water is sometimes retained in basins or hollows in the impermeable layer on which it rests. When the surface

of the land in any place dips to the level of the subsoil water, this flows out, forming a spring. Springs may also be formed when water has, in an elevated part of the country, entered between two impermeable layers, which slope downwards into a lower part of the country, and any holes or fissures in the upper layer permit the escape of water through it. Very deep wells, which are sunk into a water-bearing layer of this kind lying under an impermeable layer, are called artesian* wells; the water in such wells often rushes up with great force, as may be seen at Pondicherry.

Drinking waters have been classified as to source and wholesomeness as follows †:—

Wholesome.	1. Spring. 2. Deep well. 3. Upland surface.
Suspicious.	4. Stored rain. 5. Surface from cultivated land.
Dangerous.	6. River to which sewage gains access. 7. Shallow well.

Water from any of these sources may be clear and of agreeable taste. Each of these natural sources of water has now to be considered.

Spring water is not likely to contain dangerous organic impurities: it generally contains very little organic matter of any kind, except when the spring is derived from alluvial soil; but it is sometimes highly charged with mineral matter, which may render it unwholesome for drinking or so hard as to be unsuited for cooking and washing. As a rule, however, spring water is excellent for drinking. Artesian wells may be regarded as springs.

Deep-well water is generally similar in character to spring water, but it is more liable to contain impurities derived from the soil through which the well is sunk, or to be fouled by pollution from the surface. If much water be drawn from a well, the level of the water in it is lowered below the general level of the ground-water; the latter, therefore, for some distance around, flows towards the well and becomes depressed in the shape of a funnel with curved sides of which the surface of the water in the well is the

* From Artois in France when the first celebrated one was sunk.

† By the Rivers Pollution Commission (England).

apex (see figures). All the drainage which filters through the soil above this funnel-shaped depression of the ground-water must pass into the well, and any surface pools or deposits of filth within a considerable distance around a well are thus likely to contaminate its water. The more a well is used, the deeper and wider becomes the depression of the ground water, and the more likely is such contamination to occur. Lining the upper part of a well with impermeable masonry does not protect it from this. It is true that surface filth may have to pass through a considerable thickness of soil before it reaches a well, and it may thus be effectually filtered for a time; but if the surface pollution be continued, the soil eventually becomes contaminated throughout and it ceases to act as an efficient filter. Fissures in the soil may even allow of direct communication between wells and drains, sewers, surface pools, or other sources of contamination. The distance, at which surface contamination may affect a well, depends upon the local circumstances of each case. The height and direction of flow of the subsoil water, the depth of a well and the amount of water drawn from it, and the nature of the soil are the principal circumstances which have to be taken into consideration. No possible source of contamination should ever be allowed to exist within 20 or 30 yards of a well, and this is often much too near to be safe. One eminent authority * considers that "the well should be at a distance of not less than 200 yards from the nearest house or drain, or cess-pool, or other source of sewage pollution." Wells should not only be placed at the greatest possible distance from any source of contamination, but on that side of it, from which the subsoil water flows. If it cannot be ascertained in what direction the water moves, it may be taken for granted that it is with the general slope of the surface of the ground, such being usually the case. The upper portion of a well ought to be lined with impermeable masonry to prevent the entrance of direct drainage from the upper layers of the soil, which are the most impure. The ground should be made to slope away from the mouth of a well, and be paved with impermeable masonry for some distance round the mouth to prevent surface drainage from finding its way directly into the well or down on the *outside* of the masonry tube of the

---

* Dr. Frankland :—Evidence before Committee of House of Commons on Public Health Amendment Bill, 1878.

well. As an additional safeguard against such occurrences, the soil around the tube of the well ought to be puddled to as great a depth as possible. In places where the ground water is high, the level of water in wells must also be high; but even in such places there is much difference between deep and shallow well waters, although the water stands at the same level in both. The shallow wells receive the surface drainage which may have passed through only a few feet of probably polluted soil: the deeper wells, with a water-tight masonry tube, tap the lower layers of ground water which have filtered through a considerable depth of soil. It may be suggested that in such cases it would be advantageous to sink wells on the tops of any hillocks or high ground, so as to prevent surface percolation and obtain water filtered through the greatest possible thickness of soil. It is advisable that the mouth of a well should be small in order to prevent the entrance of dead leaves, insects, dust, and impurities of all kinds as much as possible. For drawing water from a well, a pump or a public bucket should be provided, and no person should be permitted to employ a private vessel for the purpose; such a vessel may be dirty and perhaps introduce disease germs into the water. Wells require to be cleaned out occasionally, and provision should always be made for this, which may be most conveniently done at the end of the hot weather when the water is lowest. The water of a well, which has not been cleaned out for a long time and has not been in constant use, will be found to contain an excessive quantity of organic matter. If a well has been disused for some time, it should always be cleaned before being again brought into use. With attention to the above-mentioned points deep wells form one of the best possible sources of water-supply.

Upland surface water is the surface drainage of hilly ground, and its nature depends upon the nature of the surface soil. The water is usually collected by channels passing along the bases of the hills and delivering into storage tanks or lakes. When the collecting surface consists of granitic or other igneous rock formations, with little vegetation and no habitations upon it, such water is very soft and pure. Most commonly, however, the receiving area is covered with jungle or grass, and the detritus of this vegetable matter is carried down with the water during the rains, some of it remaining dissolved or suspended in the

water, while the heavier portion, mixed with clay or sand, forms the alluvial sediment or silt which is deposited in the bottom of tanks and lakes. Water derived from a surface of this kind is soft and contains little mineral, but a considerable amount of organic impurity of vegetable origin. Of this nature are most of the tank waters in Mysore, Hyderabad, and the Deccan districts. When the surface soil or rock contains soluble mineral substances, they will be more or less dissolved by the water which flows over it; for instance, some surface waters in Salem and Bellary become thus impregnated with magnesium carbonate from *magnesite* rock, some in Coimbatore and other places with calcium carbonate from limestone rock, and some in the southern districts with nitre or with common salt from the soil. It must be remembered that upland surface water, if at all near a village, is habitually defiled by the inhabitants and by domestic animals, the banks of a tank being converted into a latrine and its water used indiscriminately for receiving ordure and urine, for washing the person and clothing, and for drinking. Hence it is most necessary that any tank, the water of which is used for drinking, should be very strictly guarded from such pollution. Water derived from malarious jungles, or contained in nullahs, pools, or tanks in a malarious country, is probably dangerous and liable to produce malarial fevers in those who drink without previously boiling it. With this exception, it may be considered that upland surface water, if guarded from animal contamination and filtered, if need be, to remove suspended vegetable impurity, is usually a good and wholesome source of supply.

Rain-water is systematically collected, in some parts of Italy and other countries, from the roofs of houses or from prepared areas, which are paved or lined with cement, and it is commonly stored in underground tanks. With due precaution, rain-water thus collected and stored is very pure and good for drinking, while its great softness renders it the best of all natural waters for washing. Rain storage, though not very suitable to large towns where the air is impure and dust abundant and where pollution of tanks might easily occur, would form the best possible source of supply for drinking purposes in those parts of the country where well water is brackish * or hard, and where pure surface water is

* Cornish recommended its use many years ago in parts of Malaba where the well water is bad.

not obtainable, and it deserves the special attention of district and village authorities and all large householders in every place which does not possess a good supply of drinking water from other sources. In some cases, even where a good supply might be obtained from deep wells, rain-water storage may be found more economical both as to first expense and as to secondary cost of raising water. Deep wells are preferable for the one reason that they are less liable to filth contamination. If rain-water storage be adopted, it is essential that the cleanliness of the receiving area, filters and storage tank should be regularly attended to. The receiving area may be the roof of a house or a sloping surface of ground paved with stone or cement and enclosed by a wall or fence. A ground area is preferable to a roof because it is more easily inspected and cleaned. The size of the receiving area required to collect a given quantity of water in a year will depend upon the local rainfall, 25 per cent. being deducted for loss by evaporation, &c. The method of calculation will be described in the section on water-supply of villages. Rain water thus collected contains impurities derived from the air through which the rain falls and the area upon which it is received, for the removal of most of these it should pass through a simple filter of gravel or sand before it passes to the storage tank. The capacity of a storage tank ought to be sufficient to contain enough water to last through the longest drought. The walls of the tank should be water-tight to prevent leakage and the entrance of impurity from outside, and the tank should be covered over, apertures being provided for ventilation and cleansing. The deeper the tank in proportion to its capacity, the less will be the loss from evaporation. Such reservoirs may, with advantage, be excavated in the solid rock wherever this is possible. The use of covering over a reservoir is not only to exclude dust and prevent fouling by birds and other animals, but to shut out light and heat, and thus to discourage the growth of vegetable and animal life in the water and to limit loss by evaporation. A depth of at least 14 feet is also advantageous in storage tanks, open or covered, for the same reasons.

Rain water, besides being stored in this way, may sometimes be usefully employed as a secondary source of supply to improve the quality of well water which is hard or brackish. For this purpose the collected filtered rain water may be led into the well instead of into a storage tank.

Surface water from cultivated land is far more likely to be dangerously contaminated than water from any of the sources previously mentioned. The land around villages is commonly fouled by the inhabitants who resort to the edges of fields or their neighbourhood for purposes of nature and wash themselves in irrigation streams. Such water is usually also polluted with the ordure and urine of domestic animals and with whatever manure is applied to the land; besides which it is certain to contain much vegetable detritus and perhaps mineral impurity. Therefore, it should never be used unless no better water is obtainable, and then it should always be purified by filtration and boiling. Water from cultivated land which is not manured and has no houses or villages upon it, may be of good quality.

River water is always dangerous in India, except the water of mountain streams in uninhabited localities. During the rains, all kinds of surface dirt and filth, which has accumulated in nullahs, is washed into rivers, and the water is also turbid with suspended clay; and at all times the water of rivers and canals, which pass near villages, is polluted by the inhabitants. Sometimes dead bodies are cast into streams, or buried or burnt in their beds when the water is low. The water of streams which flow through malarious jungles may communicate malaria. River water should, therefore, not be used if better water be obtainable, and if it has to be used it should be carefully purified. Deep wells sunk in or near rivers sometimes yield good water.

Shallow well water is the worst of all waters. Some of the shallow wells in or near villages are no better than cesspools, and the people often drink their own diluted ordure and urine, mixed with those of domestic animals, and the washings of their bodies, clothes, and household utensils, along with all the other dirt which may find its way into the water from the surface and from the air. What wonder that such people are never free from intestinal parasites, and that they are debilitated and die by millions from diarrhœa, dysentery, cholera, and fevers? What wonder that their soil should be "the breeding-ground of cholera"?*

* The ancient Hindus were apparently more careful in avoiding defilement of water. Menu and the Shastras frequently inculcate personal cleanliness and ablution; but Menu also says that no man should cast into tanks "either urine, or ordure, or saliva, or cloth, or any other things

Wells or small tanks which are more or less protected from direct surface contamination by masonry walls or steps are much better than ordinary shallow wells, but even they are liable to constant pollution from the feet of those who draw the water and from dirty utensils, and owing to their large open mouths they collect dead leaves and dust from the air in large quantity. One of the most urgent and primary sanitary measures required everywhere in India is the filling up of surface pools and dangerous shallow wells. While such sources of disease and death remain patent in every direction, municipal and local boards can have no excuse in not finding profitable employment for all the funds which are at their disposal for sanitary purposes.*

Natural Purification of Water.

Purification of water constantly occurs in nature. Subsoil water is surface water which has been purified from suspended matter by filtration through the earth. Organic impurities, whether suspended or dissolved in water, are gradually destroyed by oxidation, the oxygen which is dissolved in all natural water being the main purifying agent. The oxygen of the air also acts directly upon impurities at the surface. Water in commotion becomes much more rapidly purified than still water, because the impurities are constantly being acted upon by fresh portions of oxygenated water after they have removed the oxygen from the portions of water with which they were first in contact, they are exposed to atmospheric oxygen as they are tossed about on the surface, and the water is kept well oxygenated by free exposure to air. The presence of certain microphytes appears to be necessary for the destruction of many organic impurities; putrescent nitrogenous matter is converted by them into ammonia, and this is further converted into nitric acid. This destruction of organic matter is of the nature of a fermentation, and is analogous to the conversion of sugar into alcohol by the action of microphytes in the presence of oxygen. Water

---

soiled with impurity, nor blood, nor any other kind of poison." (Kanny Lall Dey).

* "Sanitary allotments made by Municipal Councils amounted, in 1884, to six lakhs and-a-half. . . . Of the total allotment, only Rs. 3,84,751 or 58·7 per cent. had been expended before the close of the year."—(G.O. Madras, 19th Aug. 1885, No. 1956, Public). Matters have since improved a little.

Plate II.

Filters and Wells.

1. **Barrel filter**, made with two half casks, or with boxes, or pots, holes being bored near the bottom of the outer one, higher up in the inner one, and the space between them being filled with clean sand or broken charcoal. This filter is placed *in* the water, which filters through to the inner vessel. If casks are used it is advantageous to char them inside.

2. **Partition filter.** The partition is perforated at the bottom. In the figure S is sand, C charcoal, *a* unfiltered, and *b* filtered water.

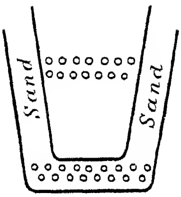
3. **Percolation filter** of ordinary pattern. CC is the filtering material which is kept in place by a perforated plate fixed with a screw.

4. **Village filter**, suitable for rain water before it passes to storage tank. *a* small settling-reservoir for catching the larger and heavier impurities, to be cleaned out frequently; *b* exit pipe for filtered water; *c c c* perforated partitions of iron or stone; *d* clean gravel or fine granite chips; *e* broken charcoal. All the spaces have covers.

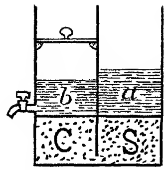
5. **Compound partition filter.** Plan of that at General Hospital, Madras $\frac{1}{120}$. 1 inflow, 2 overflow, 3 outflow. *a* coarse granite chips, *b* fine granite chips, *c* and *d* vegetable charcoal weighted down with wire netting and stone, *e* fine sand.

6. **Diagram of a well** to show effect of use in extending the surface area directly drained by well. 1 surface of ground, 2 level of subsoil water, 3 impervious layer. A well which is little used, say to lower the water to *a*, drains directly a comparatively small surface; while, if the well be much used, to lower the water to *b*, the area is greatly extended.

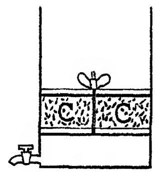
7. **Diagram of a well**, showing funnel-shaped depression of subsoil water, direct pollution of the well by a manure heap *a* within its immediate drainage zone, and pollution of subsoil water, which *may* affect the well, by a distant cess-pool *b*.



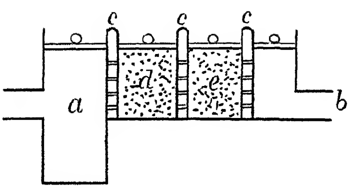
1.



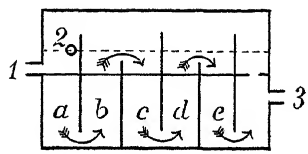
2.



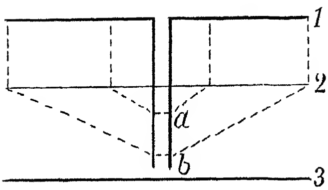
3.



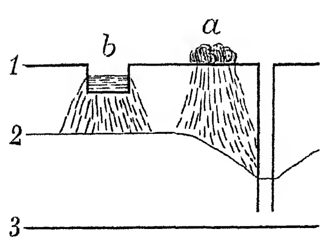
4.



5.



6.



7.

containing organic impurity when stored, as on board ship, often becomes offensive and unfit to drink during such a process of self-purifying fermentation or "sickening," afterwards becoming clear and sweet. The first part of the fermentation results in the production of offensive and often poisonous substances of the nature of ammonia, which render the water unfit to drink, and the second part in the oxidation of these substances into harmless nitrates. The latter are taken up as nourishment by growing plants. Such a process of "sickening" and self-purification may be seen annually in the river Cooum, at Madras, in April or May, the water becoming first green and extremely offensive, and afterwards comparatively clear and sweet. Subsidence of suspended matters is another very important natural purifying agency in water. River and tank waters are highly charged with fine clay during and for some time after the rainy season. The clay gradually subsides to the bottom and carries down along with it most of the suspended organic matter.

Artificial Purification of Water.

The artificial processes employed for the purification of water are oxidation, precipitation, boiling, distillation and filtration.

Oxidation is promoted by agitation and free exposure to air, as by causing a stream to flow down a series of steps or letting water fall through the air in drops or divided streams from small holes. Potassium permanganate* is a powerful chemical oxidising agent which may be employed for purifying drinking water, a few drops of its solution being added from time to time until a faint pink tinge is permanent. Iron and charcoal immersed in water or used as filtering materials have also an oxidising effect.

For *precipitation* of suspended matters, four or five grains of alum, dissolved in a little water, may be added to each gallon of water to be purified. It acts best on hard waters, and causes a precipitate which slowly subsides, carrying with it most of the suspended matters. Suspended clay, as well as organic matter, may often be removed in this way. The fruit of *strychnos potatorum* rubbed on the inside of water-vessels causes a precipitate which acts in a similar way. Tea also precipitates organic impurity. Much of

---

* *Condy's fluid* is a solution of this salt.

the suspended impurity will often subside to the bottom if water be allowed to rest for some hours. Lime is a valuable softening and precipitating agent for some hard waters, but it can only be safely employed under skilled supervision.

Boiling is the best of all ordinary methods for the destruction of dangerous organic impurities in water. If water, which is known or suspected to be contaminated with animal or vegetable impurity, has to be used for drinking purposes, it should always be well boiled, whether any other process of purification be resorted to or not. In a malarious district, unless water is known to be safe, it is always advisable to boil it shortly before use. The effect of boiling is to destroy living organisms, whether vegetable or animal, to cause the destruction of some of the other organic impurities, to precipitate calcium and magnesium carbonates, if they are present in any quantity, and to expel dissolved gases. Some kinds of hard water (whose hardness is due to the abovenamed salts and carbon dioxide) are rendered soft by boiling. The only undesirable effect of boiling is the expulsion of the air gases from water; it is thus rendered less bright and palatable.

By *distillation* water is obtained in a nearly absolutely pure state. This method is used for obtaining potable water from sea water on boardship and in places where no fresh water exists, such as Aden.

Filtration is the most common and often an efficient method for purifying water, both on a large and small scale. It has the effect of removing suspended matters, though extremely minute particles of clay and the spores (seeds) of microphytes are capable of passing through ordinary filters. Microbes are mostly arrested by deep sand filters, such as are employed on a large scale, but household filters are often worthless for removing them. Dissolved impurities are also removed to some extent by filtration, and some filtering materials, such as charcoal and spongy iron, have considerable power in oxidizing organic matter. For filtration on a large scale gravel and sand are used, about 3 feet of gravel, coarse at the bottom and gradually finer towards the top, being overlaid by 2 feet of fine clean sharp sand. The surface of the sand requires to be scraped off from time to time to a depth of half an inch or more and replaced by clean sand. The water on such a filter should not exceed 2 feet in depth—less is better—and it should not pass through

faster than about 6 inches per hour, so as to deliver about 75 gallons per square foot of filtering surface in 24 hours. It is a general rule with all filters that slow is more effective than rapid filtration. For filtration on a small scale, sand, charcoal, charcoal mixed with silica or other substances, spongy iron, and various other materials are employed.* The "three-chatty filter" is efficient, if the sand and charcoal employed are clean and renewed from time to time, and if the pots be kept clean and protected from dust; but the filtered water is very apt to be fouled by vessels dipped into the bottom chatty or insects and dust falling into it; and the waterman, to save himself trouble, may pour unfiltered water directly into it. It is better, therefore, to have the filtering vessel fitted close to the reservoir vessel which contains the filtered water. Whatever kind of filter be employed, it must be remembered that it requires periodical cleaning—a chatty-filter ought to be cleaned once a week, others less frequently. When a filter becomes foul, it is much worse than useless, and, instead of purifying, may give impurity to water. The need of frequent attention and cleansing is the greatest objection to filtration on a small scale by household filters. In the case of town-supplies, where the water is filtered on a large scale, the cleaning of filters is systematically performed and periodical analyses are made to detect any fault in purification.† Sand may be purified by washing it with clean water and spreading it out in the sun for some days, or by strongly heating it over a fire. Charcoal is perfectly purified by heating it strongly in a *closed* vessel. All filters, except those containing iron, may be purified by passing through them a solution of potassium permanganate (20 grains to a quart of water acidulated with 10 drops of sulphuric acid), followed, after an hour or more, by a quantity of clean water acidulated with a little hydrochloric acid, and finally

---

* Bischof discovered the value of spongy iron. Scrap iron mixed with sand or charcoal has also a good effect. It acts chemically by becoming oxidised and yielding its oxygen to organic matter. Pasteur used porous porcelain; this material was found by Burdon-Saunderson to effectually remove septic poison (spores of bacteria or micrococci) from water, but filtration through porcelain requires considerable pressure.

† As an illustration of the necessity of supervision and attention to details in filtration, an instance may be mentioned in which, after the construction of a tank-filter for a large public institution, the water was found to be in no way purified. On examining the filter, I found the water flowing *over* the partitions no overflow pipe having been provided in the first chamber.

some pure water. Diagrams of various useful forms of filter are given in the plate annexed.

WATER-SUPPLY OF TOWNS.

The question of water-supply for large towns need not occupy much space here, because it is a question which should in every case be referred to the consideration of highly-trained sanitary and engineering experts. Some knowledge of it, however, must be regarded as indispensable for all municipal authorities.

The water should, as a rule, not be derived from any source within a town. Surface wells should on no account be used, and any which exist ought to be filled up with earth. Even deep wells situated in towns are very liable to pollution; the more they are used, the more likely are they to be fouled, for, according as the water is lowered, the area drained by a well is increased; and the chances of direct pollution are manifestly greater in towns than in the country. Rain-water collected in large towns is also apt to acquire dangerous impurities from dust in the air and dirt on the roofs of houses. The water-supply of towns should, therefore, be obtained from a pure source outside. Springs, deep wells, upland surface-water, and filtered river-water, are the sources from which towns may be supplied; and the source available or the one selected where there are several must depend upon local circumstances in each case. With regard to quality, it is desirable that water for a public supply should be not only free from dangerous organic and mineral impurities, but that it should be *soft*. Hard waters are not good for washing nor generally for manufacturing purposes, and they may cause blocking of pipes from calcareous incrustation; while the only possible objection to soft waters is that they are more likely to act on leaden pipes. The quantity of water required per head of population depends largely upon local circumstances, such as the use of public and private baths, water-closets and latrines, sewerage, clothes-washing, manufactures and road-watering. Domestic animals have also to be provided for, and good drinking water is necessary for their health.*

* Not only to prevent parasitic, but other diseases also; as an instance, not long ago a valuable pack of hounds was nearly destroyed by an epidemic of disease which Mr. Mills, A.V.D., pronounced to be *dog typhoid*. The water, which they drank, was found by the author to be polluted with house-refuse and to contain swarms of bacteria.

Clothes are frequently washed in very foul water; and the construction of public troughs or wash-houses, supplied with pure water, for the use of washermen free or on payment of a small rent, is a matter which deserves the attention of municipalities.

There is always a good deal of wastage in public water-supplies, and much of this is often preventable by proper control. Such control is most necessary when the supply is limited, or when the water has to be pumped up at considerable expense or to be purified, or when it is important to limit the quantity of sewage outflow.

In cases where the supply of good water is limited, it may be necessary to use it only for drinking and cooking, water for other purposes being obtained from less pure sources. A dual supply of this kind is, however, very objectionable, because it is certain that careless people will use for all purposes any water which is most easily obtained.

The quantity of water required for drinking and cooking may be set down as 1 gallon per head of population daily, and for all purposes 12 gallons per head is a sufficient, and 15 gallons an ample, supply for a town, if waste be prevented. With a large margin for waste and ornamental fountains and gardens, 30 gallons or more may be used.

If a sufficient supply be obtainable from the source at all seasons, small storage tanks only will be required; but if, as is frequently the case, the supply fails or runs short at certain seasons, it will be necessary to provide one or more storage tanks or reservoirs of sufficient capacity to contain a supply of water which shall last through the longest period of drought. Thus, for the storage of upland surface water and river water in places where there is a long rainless season and sometimes a deficient rainfall, very large storage tanks, such as the Red Hills tank near Madras, have to be constructed. It is advisable that no habitations or manured lands should exist in the area or catchment basin which supplies the storage tank. If such exist and cannot be removed, it may be possible sometimes to cut off their drainage from the tank by the construction of intercepting drains. Storage tanks should, if practicable, be placed at a sufficient elevation to supply water to the town by gravitation; otherwise the water must be pumped to a sufficient height for the purpose. If the source or storage-tank be at a great distance or at a

considerable elevation, it will be necessary to provide one or more secondary reservoirs, such as that at Kilpak near Madras.

Purification of the water is generally required, except in the case of good spring, deep well, or mountain water, before it is delivered to the town. Filtration through gravel and sand is the usual method of purification. A filter bed is a shallow tank with concrete or cement floor and walls, the floor being grooved with small channels leading to the main exit channel. Clean gravel, coarse below and of increasing fineness higher, is laid on the floor to a depth of 3 feet and over this fine clean sand to a depth of 2 feet. The water to be filtered is flowed over this to a depth of never more than 2 feet. At least two filters should be provided, so that one may be used while the other is being cleaned. Muddy water should be allowed to stand for some time in a settling tank, that most of the mud may subside before it goes to the filter. The filtered water should be stored in a covered cement-lined tank. Aqueducts or channels for conveying water require great attention to prevent fouling of the water in them. The Romans carried pure water from great distances into towns by solid masonry aqueducts, laid sometimes underground and sometimes supported on lofty arches according to the level of the ground. These aqueducts were so well built that the city of Rome still possesses a copious supply of excellent water delivered by several of them. Large iron pipes are now generally used for the purpose and they are found more convenient and less expensive, as they may be carried over undulating ground and support considerable pressure. They should, however, be bedded on firm foundations to prevent leakage at joints, and valves or taps must be provided at the summits of upward and the bottoms of downward curves to allow of the removal of air or of silt. Open channels, such as that leading from the Red Hills to Kilpak, are very objectionable; and can never be properly preserved. For delivery of the water in the town iron pipes or pipes made of lead with a lining of block tin should be employed. Lead pipes or cisterns should be generally avoided in India, for most Indian waters contain a considerable amount of nitrates and may become poisonous by contact with lead. Peaty waters are very apt to attack lead. Hard waters, and, especially those containing silica,

are not likely to dissolve lead.* Unfiltered muddy water, such as Red Hills water at some seasons, is apt to cause choking up of pipes from silt, and some kinds of hard water produce the same effect by a deposit of calcareous material on the interior of the pipes. Fish, or other animals alive or dead, may enter water-pipes with unfiltered water or through leaky filters † and cause stoppages in pipes or pollution of the supply. Hence it is desirable to filter all public supplies before distribution.

Water-pipes, especially in a descent,‡ are likely to admit gaseous, liquid, or even solid impurities through leaky joints; care should therefore be taken not only to provide solid foundations for such pipes, but to avoid laying them in polluted soil or close to sewers. If this cannot be avoided, the pipes should be bedded in concrete.

The distribution of water in a town should be such as to place an abundant supply within easy reach of every house. Numerous public fountains situated at convenient centres will be found sufficient and safest in most cases; but, if the supply be constant, separate supply pipes may be laid to private houses and public buildings, and the pressure of water ought to be sufficient to carry it to the top of the highest building in the town. Taps should be inserted at convenient intervals in the water mains laid through streets, in order that a ready supply of water may be obtainable for extinguishing fires, and, if possible, for watering the roadways. The supply and pressure of water should be as *constant* as possible. An *intermittent* supply is very liable to contamination: when the water is shut off foul air or liquid and even solid matters are likely to be sucked into the pipes through leaky joints or open taps.§ If, for repairs or other reasons, the supply has to be shut off for a

* Waters containing less than 0·3 gr. per gallon of silica all act more or less on lead; those containing more than 0·5 gr. per gallon never act upon it. Contact with limestone mixed with broken flint for five minutes was found to render "lead-proof" — a water which previously dissolved lead. (*Crookes, Odling, and Tidy, Brit. Assoc.*, 1886.) It would therefore be a wise precaution to place some broken flint, or other siliceous stone, with the gravel in filters wherever leaden pipes or cisterns are employed.

† Eels have lately obtained access to the pipes of one of the London Water Companies in this way and have caused much annoyance. Fish are sometimes found in Madras water-pipes.

‡ *Buchanan*, Rep. on Croydon supply.

§ There are several well-authenticated cases in which this has occurred, and in which disease has been thus distributed.

time, danger may be obviated, when the water is turned on again, by leaving some of the terminal taps open until the pipes have been sufficiently flushed.

In cases where there is a threatened failure of the water-supply of a town, owing to a long drought or other cause, the common and, as above pointed out, dangerous practice is to render the supply intermittent by shutting it off, except during certain stated hours daily. Danger would be avoided and waste would be better controlled if, instead of shutting off the main supply, municipal authorities were, in such cases, to seal up a number of the least required taps and fountains, and, if necessary, to limit the flow of taps by the insertion of perforated plugs or some similar device.

To render the water-supply of a town perfect, it is necessary, not only that an abundant supply of pure water should be distributed to every part, but that every local source of polluted water should be closed. It is well known that numerous foul wells and tanks exist in Calcutta, Madras, and other cities and towns, which possess a comparatively good public supply of water, and that the inhabitants make free use of such contaminated sources, even in the close vicinity of public fountains. So long as filthy and *contaminable* * sources of water are allowed to exist within municipal limits, no town, however pure and abundant its public supply may be, can be considered well supplied with water or safe from outbreaks of those diseases which are communicable through water.

The calculation of water-supplies for towns, the construction of weirs, storage tanks, well-tunnels, &c., and many other matters relating to large water-works are peculiarly the province of sanitary engineering experts and cannot be discussed here.

Water-supply of Villages.

The town population bears only a small ratio to the rural population in India; the water-supply of villages therefore demands even more attention than that of towns. Towns can generally command the services of specially-trained and experienced sanitary and engineering authorities; but villages have in most cases to depend upon their own or their district officers for advice and supervision

* A word coined, I believe, by Sir John Simon.

regarding the water-supply, and indeed for sanitary improvement generally. Hence it is most important that those officers should be capable not only of giving advice, but of carrying their advice into practice. Many portions of the preceding remarks as to the qualities and sources of waters and the water-supply of towns are equally applicable to the supply of villages and detached houses, and they should be borne in mind when reading the following observations which are particularly intended for village authorities and house-holders.

We shall consider the water-supply of villages with regard to source, quantity, purification and distribution, premising that combined action on the part of the inhabitants will usually be required to secure a really satisfactory and safe supply.

Existing sources should first be examined and their water should be tested with the view of deciding whether one or more of them may be used for a general supply and whether they are capable of improvement or not.

Springs are rarely available, and the choice of good sources will generally be between deep wells, stored rain, and upland surface water. Deep wells and upland surface water have been already sufficiently discussed. Stored rain water is, however, such a valuable source, and one so little used in India, that some further remarks upon it may be useful. From this source pure drinking water could be readily obtained in places where well waters are brackish or unwholesome from their hardness and the presence of magnesium or other mineral impurities or from organic impurity, and where surface waters are liable to contamination. Such places exist in nearly every district. Large surfaces of rock may sometimes be utilized as collecting areas, the water being received in a channel cut along the lower edge of the surface and delivering with the intervention of a small filter into the storage tank. A suitable form of filter is figured in the plates annexed. If a rock surface is not available, stone or brick may be employed for paving the selected area, or its floor may be puddled and lined with mortar or, what is better, Portland cement. The surface ought to have a sufficient incline to allow the rain to run off rapidly, and thus limit the loss by evaporation. The prepared area must be surrounded by an impenetrable fence or high wall, to prevent its defilement by men or other animals. A prepared surface of this kind is

better than a house roof for collecting rain, being more easily inspected and cleaned, and roof is not generally large enough to yield a sufficient supply. It may be found convenient in some cases to use both roofs and ground areas. If it be determined to supply a whole village with rainwater it is much better to have one large properly-made collecting surface and storage tank, which can be more easily looked after and kept clean than several small ones.

The *quantity of water* required, and the consequent size of the collecting area, will depend upon whether water for all purposes, or only for drinking and cooking, is to be supplied from this source. In places where the rainfall is sufficiently abundant, and where a large collecting surface can be provided, it may supply water for all purposes, at least 5 gallons per head (including children) daily being allowed. In places where the rainfall is scanty, or where long periods of drought are frequent, it may be possible to supply only water for drinking and cooking purposes from it, at least 1 gallon (8 pints) per head daily being allowed. To calculate the size of the collecting surface required, the first thing to ascertain is the average rainfall for as long a series of years as possible. If no observations of rainfall have been made at the place itself, the records of the nearest meteorological station may generally be accepted. One inch of rainfall yields a little more than half a gallon (0·5198) for each square foot of surface. The method of calculation can best be explained by an example. Let us suppose that it is required to obtain a supply of 5 gallons per head daily for a village containing 450 inhabitants, the average annual rainfall of the place being 28 inches. The total quantity of water required in the year will be the population multiplied by the daily amount per head multiplied by the number of days in a year, $450 \times 5 \times 365 = 821{,}250$ gallons. As each inch of rain yields half a gallon on a square foot, 28 inches yield 14 gallons on each square foot, and $821{,}250 \div 14 = 58{,}661$, which is the area in square feet necessary to collect the required supply. As an allowance for wastage by evaporation, leakage, &c., 25 per cent may be taken, thus making the area $\frac{58{,}661 \times 4}{3}$ or 78,215, square feet, that is, a space measuring, if square, $\sqrt{78{,}215}$, or nearly 280 feet on each side.

The average annual yield in gallons of any existing surface may be calculated by measuring its *horizontal* area

in square feet, multiplying this by half the average annual rainfall in inches, and deducting one-fourth for wastage. If the incline of the surface be slight, no allowance need be made for its divergence from a horizontal plane; but if the incline be considerable a correction must be made, for instance, a pointed roof must be reckoned as a flat roof, covering the same house. Any surveyor, or other person accustomed to take levels, can easily make the required calculations for a ground surface.

The construction of a *storage* tank for rain water has already been alluded to: its capacity has now to be discussed. In most parts of India very little rain falls during the first six months of the year: storage for at least six months' supply will therefore be required. The rainfall of the driest year likely to occur may be taken at not less than half the average rainfall, and in such a year only half the usual supply would be collected. It may therefore be generally reckoned that a good storage tank ought to have a capacity equal to nine months' supply—that is, three-fourths of the annual requirements. In the case above supposed of a village with 450 inhabitants requiring 5 gallons each daily, or 821,150 gallons in a year, the storage tank ought to have a capacity of $\left(\frac{821,250 \times 3}{4}\right)$, or 615,938 gallons, or nearly 98,700 cubic feet. (6·24 gallons = 1 cubic foot). A reservoir, 23 feet deep, 23 feet wide, and 172 feet long, would have the requiste capacity, and it should, if possible, be covered over. In any case it should be protected by a fence.* Storage tanks ought to be built in two or more compartments for convenience of cleaning.

Although unfortunately the circumstances of few Indian villages would admit of the construction of reservoirs of this kind to supply 5 gallons per head daily, yet many villages could probably afford to construct reservoirs to furnish drinking water only. An area and tank of the size mentioned would be sufficient to supply drinking water only (1 gallon per head per day) for a population of 2,250 persons.

If the catchment area were considerably increased, so as to take better advantage of occasional showers during

---

* Works of this kind, being permanent improvements, ought to be constructed when needed by Taluk Boards, the capital expenditure being made repayable by instalments spread over a considerable number of years.

the dry season and light monsoons, the storage tank might be made smaller still. If this were done, and if care were taken to restrict the consumption to actual requirements in times of drought, a storage tank to contain only a four months' supply (at 1 gallon per head daily) might be made to suffice in many places.

Smaller reservoirs would be very useful in places where deep wells yield a good supply at certain seasons of the year, but occasionally run dry. The reservoir could be filled from the well and used as a reserve source when the well ceased to yield.

A less costly plan * than that of masonry tanks would be to store the water in an ordinary bunded tank, with sides and bottom puddled, allowing for increased evaporation and other loss by enlarging the catchment area and storage capacity.

Existing small tanks might in some instances be improved and utilized, at no great expense, so as to furnish a supply of usable, if not very pure, water protected from contamination. For this purpose the tank should be deepened, both it and a sufficient catchment area being well puddled, to render them water-tight, and tank and area being surrounded by a good fence. An intercepting drain would also be required in most cases to prevent surface water, except what flowed from the prepared area, from entering the tank. The growth of aquatic plants would be beneficial, and should be encouraged in a tank of this kind if it be shallow.

Surface water, collected in open tanks, may be sometimes employed; but it is very difficult to preserve open tanks from pollution when they are situated near villages. Surface water, even if collected from an unpolluted surface, must, at all events, contain a good deal of vegetable impurity, and it requires more careful filtration than rain-water collected on a prepared area. No fixed rules can be laid down for the calculation of the quantity of water obtainable by collection in an open tank from a surface which is not water-tight; it depends largely upon the porosity and inclination of the soil and the depth of the tank.

The supply which a well is capable of yielding may be estimated by pumping out a large quantity of, or all, the

* Suggested by my friend, Captain H. D. Love, R.E., to whom I am also indebted for revisions and corrections in the foregoing paragraphs.

water, measuring the space from which the water has been removed, and observing the time which it takes to fill again. The cubic space (contents) may be calculated by multiplying the cross area (horizontal section) of the well by the depth of water removed. Wells are generally circular or rectangular in cross section: the area of a circle is the square of its diameter multiplied by 0·7854, and of a rectangle its length multiplied by its breadth. Say, for instance, the water in a circular well, 3 feet in diameter, is found to be 12 feet deep. A mark is made to register the water level, and the well is pumped dry. The time from the cessation of the pumping until it fills again to its former level is noted, and is, let us suppose, five hours. $3 \times 3 \times 0{\cdot}7854 = 7{\cdot}07$ the cross area of the well in square feet; this multiplied by $12 = 85$ cubic feet nearly, the contents of the well. Now 1 cubic foot $= 6{\cdot}24$ gallons; the contents are therefore 530 gallons; and, this quantity being yielded in five hours, the quantity which can be yielded in twenty-four hours will be ($5 : 24 :: 530 : x$) 2,544 gallons. It must always be remembered that the yield of wells may vary greatly according to season and in different years.

The yield of a small stream may be ascertained by noting the time it takes to fill a vessel of known capacity, or by digging a pit of certain dimensions, turning the stream into it, and noting the time it takes to fill.

In the *distribution* of village water-supplies various improvements are feasible. The present ordinary plan of drawing water in private vessels should on no account be allowed, because impurities, including the virus of some diseases, may be thus conveyed to a well and distributed in its water. A public bucket with a rope and windlass, or a pump, is much safer. A still better arrangement would be to build a cistern at a convenient level, and have it filled once or several times daily, from the well or rain-reservoir or tank, by means of a pump or other mechanical elevator worked by public cattle, or by hand or water-power or a windmill. When wind or water power is employed, provision should generally be made for the use of cattle when wind or water fail. The people could then obtain water from the cistern tap without any danger of polluting the source. For larger villages the water might be raised at the source, be carried into the village by pipes or an aqueduct, and be distributed to one or more public cisterns or fountains placed at convenient centres. A good public supply for villages could

thus usually be managed at no great expense, and it would very largely contribute to the health and convenience of the inhabitants. When a public supply is provided one of the village officials should have charge of it and be held responsible for its efficiency, and for the periodical cleansing and repairs of collecting surfaces, wells, storage-tanks, filters, cisterns, &c.

Examination of Water.

Although an acquaintance with general and practical chemistry is necessary for well-qualified sanitary specialists, it is not to be expected that sanitary or medical officers in general, who are not experienced in chemical methods and manipulations, should be able to make an accurate quantitative analysis. Every sanitary officer of superior grade should certainly know enough of chemistry to clearly understand the analytical methods employed, and it is necessary that all should at least be able to read water analysis intelligently and to make a simple examination of the quality of a water. The following observations are therefore divided into two parts:—Firstly, description of an easy method for the examination of water; secondly, inferences to be drawn from complete examination by an expert. These observations have been made as simple as possible, in order that they may be readily understood and utilized by persons who possess little or no chemical knowledge.

Easy Method for examining Water.

The question of the *quantity* and sufficiency of the supply at all seasons has already been fully treated of; the examination of water as to *quality* only has now to be considered. This may be divided into (1) local, (2) physical, and (3) chemical examination.*

The *local examination* should consist of a careful survey of the source, method of raising if any, storage tanks, methods of purification, cisterns, and channels of distribution, with particular reference to any possible or probable cause of pollution.

---

* For the simple physical and chemical examination of water here described the following apparatus should be provided:—a *Winchester quart* bottle, two tall jars or bottles of white glass, a few large test-tubes, blue and red litmus paper, and solution of potassium permanganate, Nessler's test, silver nitrate, barium chloride, and ammonia, in stoppered bottles.

After this a sample of the water should be taken for physical and chemical examination. A stoppered (Winchester quart) bottle is convenient for the purpose, or two ordinary bottles with clean new corks may be used. Great care must be taken to use perfectly clean bottles. The bottles should be washed out with the water to be tested before they are finally filled with it. A fair sample of the water should be secured in the exact state in which it is drunk. It ought to be examined as soon as possible after collection, and be shaken up, if there be any deposit in the bottles, before it is poured out for testing.*

The *physical examination* includes observation of the clearness, color, taste, odor when fresh and after keeping, of the water; also (if the examiner be skilled with the microscope) a microscopic examination of the sediment. A tall jar or bottle of white glass should, if possible, be used for examining the clearness and color of a water; the jar being placed in a good light upon a sheet of white paper, a considerable depth of water may be viewed by looking downwards through it. If the water be very turbid, the depth through which ordinary newspaper print can be read may be stated. It should also be noted if any distinguishable objects, such as bits of leaves or insects or small worms, alive or dead, are present. If there be any sediment it should be observed whether it be compact or flocculent. If no color or turbidity be apparent a second glass vessel of the same size filled with distilled or other very pure water may be placed beside the vessel containing the water under examination, and the two waters can then be compared.

The taste may be readily ascertained without swallowing any of the water. To detect the odor, if any, a clean wide-mouthed bottle should be half filled with the water and shaken; on then smelling the mouth of the bottle any odor will be evident. If no odor be perceptible, the bottle half-full may be stoppered and set aside for twenty-four hours, when it should again be shaken and smelled, or, if it be desirable to complete the examination at once, gently warming

---

* This has been the rule in the Chemical Examiner's laboratory at Madras for some years. The author has found different practices prevalent in various laboratories, in some the heavier suspended matters being allowed to subside for twenty-four hours, in some filtration through paper being adopted, and in others what he believes to be the correct practice of shaking up any sediment.

the water, or the addition of a few drops of caustic potash solution to it, may cause the development of some odor.

Microscopic examination will not, as a rule, form a part of this brief investigation; but, if the observer be a medical man, and be provided with a microscope, he may usefully examine any sediment. Angular particles of sand or rounded ones of clay, fragments of vegetable tissues, of insects, reddish or brownish masses of decomposing organic matter, living infusoria, or evidences of contamination with house refuse, such as starch granules of rice or other grain, portions of vegetables used as food, epithelial scales from human skin, human hairs or fibres of cotton or wool from clothes, may thus be recognised.

The *chemical examination* includes the following determinations:—reaction, organic matter, ammonia, chlorides, sulphates and magnesium.

The reaction (acidity or alkalinity) is determined by immersing bits of blue and red litmus paper in the water. Good water ought to be neutral or faintly acid (from carbonic acid). The papers should therefore remain unchanged in color, or the blue paper should become only purple or faintly reddish. If the red paper becomes purple or blue the water is alkaline.

For the organic matter test two white glass bottles, a solution of potassium permanganate (1 grain to 2 ounces of water is strong enough), and some distilled, or other water known to be pure, are required. The bottles should be marked to indicate equal measures, otherwise a glass measure will also be needed. In one bottle a measured quantity of distilled water is placed and in the other bottle an equal quantity of the water to be examined. Solution of potassium permanganate is added, drop by drop, the drops being counted, to the distilled water until it acquires a distinct pink tinge which remains after it is stirred with a glass rod or the bottle is shaken. The same number of drops of potassium permanganate solution must be added to the water in the second bottle, and mixed similarly. Both bottles are then placed on a sheet of white paper and their color is compared for a quarter of an hour. If the water under examination loses its pink color rapidly, it contains a considerable amount of organic matter, probably animal; if it loses its color more slowly, the organic impurity is more

probably vegetable; if its pink color remains with little change, it contains little organic impurity.*

For the detection of ammonia, some of the water is taken in a test tube or a bottle, and a few drops of Nessler's solution † are added. A yellow or brown color indicates the presence of ammonia or its salts. A white milky precipitate is often produced by this test-solution, and shows that the water is hard owing to the presence of lime or magnesia. The Nessler solution therefore serves to indicate hardness, as well as ammonia; the amount of whitish precipitate depending upon the degree of hardness, and the depth of yellow or brownish coloration depending upon the quantity of ammonia present.

Chlorides are detected by adding a few drops of a solution of silver nitrate, acidulated with nitric acid to some of the water in a test tube: a milky haze or precipitate shows their presence. It should be noted whether only a haze or turbidity or considerable precipitate is produced.

Sulphates are indicated by the production of a haze or cloudiness when some of the water is well shaken in a test tube after the addition of a few drops of barium chloride solution acidulated with hydrochloric acid.

Magnesium salts are indicated by the production of a similar cloudiness on shaking after the addition of ammonia solution.

The inferences which may be drawn from an examination of water according to the above scheme have now to be explained.

A yellow or green color generally denotes organic impurity which may be injurious, and a brown color may be due to clay or peat which are comparatively harmless.

---

* The presence of iron in the water will also cause decoloration. Iron, in any quantity, imparts a peculiar taste to water. To detect small traces of it, some water may be evaporated to dryness and a drop of solution of potassium ferrocyanide be added to the residue: a blue color indicates the presence of iron.

† This should be obtained ready-made, or it may be prepared as follows: 30 grains of potassium iodide and 10 grains of mercuric chloride are dissolved in a pint of warm, distilled or rain water. A strong solution of mercuric chloride is added, drop by drop, with stirring, until a slight red precipitate is permanent. 150 grains of caustic potash must now be added, and finally a little more mercuric chloride solution, until a slight precipitate is produced. This is allowed to subside and the clear solution is decanted for use.

A deeply colored water ought always to be rejected unless the cause of its color can be ascertained to be harmless. A markedly turbid water must necessarily be condemned. Flocculent sediment is usually organic. A badly smelling water is probably dangerously contaminated with organic matter and not fit for potable use. Any marked taste is usually due to excessive mineral impurity which must also render the water unfit for use.

The color, turbidity, odor, and taste of water, may thus serve as sufficient causes for its rejection; but a perfectly colorless, clear, odorless, and tasteless water, which is to all appearance very pure, may contain dangerous organic and mineral impurities. It is evident therefore that although physical examination alone may be sufficient to condemn a water, it is not sufficient to pass it as good and wholesome.

Microscopic examination of the sediment may reveal the presence of house refuse or other dangerous contamination which must condemn a water; but, as above stated, the absence of such visible impurities does not imply that the water is pure.

Any water which has passed the physical examination must therefore be further examined chemically.

A strongly acid or any alkaline reaction should condemn a water unless the cause is known to be harmless.

Water which rapidly decolorizes potassium permanganate must be regarded as dangerously polluted with organic matter (unless it is known to contain iron).

Ammonia is usually derived from the decomposition of nitrogenous organic matter. Any water containing it in quantity is therefore probably polluted, and if a well-marked color be given with the test solution the water should be condemned. Slight traces of ammonia are found in most waters.

Hardness, due to lime and magnesia, is also indicated by the same test (owing to the caustic potash contained in Nessler's solution). A water which yields much white precipitate with it is bad (though usable) for washing and cooking purposes, but may be fit for drinking if it give no indication with the tests for sulphates or magnesia.

Chlorides are contained more or less in all natural waters. If the quantity be large, it shows that the water is brackish (from common salt derived from the soil) or that is contaminated with animal impurity. Thus a considerable

amount of chlorides alone cannot condemn a water; but a very small quantity is an indication of a very pure water.

The presence of sulphates in sufficient quantity to give any turbidity with the test solution is evidence of dangerous mineral or organic contamination which is enough to condemn a water.

Magnesium in sufficient quantity to give turbidity with the test is also very objectionable and ought to condemn a water.*

The foregoing method of examination affords a fair basis for giving an opinion as to the usability of a water. If the results of the local, physical, and chemical examination be satisfactory the water may be pronounced usable; if otherwise, it must be regarded as suspicious or dangerous. In the case of doubtful water it is advisable to obtain a complete analysis, or at all events never to use it without purification. If a water be condemned on account of turbidity or of organic impurity it should be set aside for twenty-four hours in order that the sediment may subside, or be filtered, and then examined again to ascertain if may be rendered usable when purified by subsidence or filtration.

Complete Examination of Water.

A complete examination of water involves full investigations as to (1) *quantity*, storage and distribution, and (2) *quality*, protection from defilement, and purification. Enough has been said to enable the reader to judge of reports under the first head; and, under the second head, it only remains to point out the inferences which are to be drawn from chemical analyses and from microscopic and biological examinations made by experts, and to explain the value and uses of such analyses or examinations.

The ordinary analysis of drinking water made in the laboratory of the Chemical Examiner at Madras comprises the determinations which are stated below, a classification of waters according to purity (after Parkes) being also given for guidance and comparison with actual analyses. It must be noticed, however, that no absolutely fixed rule

* In making this local, physical, and chemical examination of water, it will be found convenient to record results according to a plan which is commonly adopted in classes of practical chemistry: rule the paper in three vertical columns for (1) test, (2) observation, and (3) inference.

can be laid down, and the origin of impurities, if it can be traced, must be taken into account.

Nature of impurity and how stated.	Good water contains not more than	Usable water contains not more than	Suspicious water contains not more than
Total solids—*grams per litre* ...	0·071	0·428	0·714
Volatile solids *do.* ...	0·014	0·043	0·071
Chlorine *do.* ...	0·014	0·043	0·071
Total hardness—*degrees Clark.*	6°	12°	20°
Permanent hardness *do.* ...	2°	4°	6°
Free ammonia—*milligrams per litre.*	0·02	·05	1·00
Albumenoid ammonia *do.* ...	0·05	·10	1·25
Nitric acid	0·32	5·00	10·00

Any water containing more of any impurity than "suspicious water" is generally "bad."

A short account must now be given of the meaning of each of the above determinations and the inferences which may be drawn from it when considered singly or in conjunction with other determinations.

The *total solids* comprise all the solid impurities of water, suspended and dissolved, organic and mineral. The mineral impurities are comparatively heavy, and, as a rule, form by far the largest proportion of the solids.

The *volatile solids* consist mainly of organic matter and may be regarded as a measure of its amount.

Chlorine is usually due to the presence of common salt in the water. It may be derived (1) from the sea or the soil, in which case the permanent hardness is likely to be considerable and the free and albumenoid ammonia and volatile solids may be small in quantity, or (2) from animal pollution, especially urine, in which case free and albumenoid ammonia and volatile solids will indicate recent and dangerous contamination. In the first case a considerable quantity of chlorine may be harmless.

Total hardness affords little indication of the wholesomeness of a water, since water is rendered hard by such harmless impurities as carbon dioxide and calcium carbonate as well as by noxious salts of calcium and magnesium. Hard water is not well suited for washing, cooking, and steam purposes.

Permanent hardness is a much more valuable indication, because it is entirely due to noxious mineral impurities, principally salts of calcium and magnesium.

Free ammonia, if in large quantity, is usually derived from the decomposition of urine and other animal matter, chlorine and nitrates being also increased if such be the case and albumenoid ammonia existing in some quantity.

Albumenoid ammonia is a measure of the actual nitrogenous organic matter existing in the water. If albumenoid ammonia be considerable and there be little or no free ammonia, the impurity is probably of vegetable origin, and if chlorine be also absent or in very small quantity it is almost certainly vegetable. Albumenoid ammonia co-existing with free ammonia, chlorine, and nitrates renders it probable that the impurity is of animal origin and therefore most dangerous.

Nitric acid is a result of the decomposition of nitrogenous organic matter (recent pollution of water with such matter being shown by albumenoid ammonia, which, as decomposition goes on, becomes replaced by free ammonia and nitric acid). In India nitric acid is frequently derived from nitre deposits already existing in the soil and therefore it cannot be regarded as a trustworthy index of organic contamination.* It renders water likely to act on lead.

Phosphoric acid is sometimes estimated, and its presence in water is a more certain indication of organic pollution than that of nitric acid.

The ordinary microscopic examination of water may detect evidences of house refuse, or eggs or embryos of parasites, or vegetable detritus, and thus sometimes discover the source and exact nature of contamination. Bacteria and fungi, if abundant, indicate the presence of decomposing organic matter. Other microscopic organisms, animal or vegetable, ought not to be numerous in good drinking water.

The *biological test* for water consists in the cultivation, according to Koch's methods, which need not here be detailed, of the microbes contained in the water. The number of microbes present in a measured quantity of water may thus be counted. Different microbes, however, require different methods of cultivation, and ready means of distinguishing innocent from disease-causing microbes are wanting. This method of testing can only be conducted

* My experience in this matter agrees with that of Surgeon-Major Nicholson. Vide *Lancet*, 20th October 1883.

by experts, and up to the present time it has not yielded practical results which entitle it in any way to supersede, though it may sometimes usefully supplement, chemical methods. It has been of most value in estimating the efficacy of filtration;* but it is much slower and less easily applied than chemical tests, and, for ordinary use, the latter are certainly preferable.

Value and scope of water analysis.—The principal uses of single or repeated analyses may be stated as follows:—A single analysis is necessary to ascertain the nature and quantity of the impurities in any sample of water. Repeated or periodical analyses are necessary (1) to determine the changes in water from the same source under different seasonal or other conditions, (2) to detect contamination and possibly indicate its origin, (3) to ascertain the best means and to test the continued efficiency of means adopted for purifying water.

Chemical analysis gives complete information as to the chemical impurities of water. The information it affords regarding organic impurity is less satisfactory, since it does not distinguish dangerous from comparatively harmless substances; but "practically, if a water be contaminated at all by dangerous impurities, it contains associated impurities which mark it chemically as dangerous."† Chemical examination, therefore, if not infallible, is certainly the best means we at present possess for judging the wholesomeness of a water; but with regard to organic contamination of drinking water judgment must not, if possible, be founded upon the results of chemical analysis alone. If the water be contaminable at its source or in its channels of distribution it can never be regarded as safe. Local and chemical examination of water must therefore always go together: either taken singly may often suffice to condemn a water, but both are always required to give sufficient grounds for a positive assurance of purity and safety.

Ice may be made of dangerously impure water, and the author has found the ice obtained from two large ice factories to be made with very impure water.

Aerated waters may also be made of dangerously impure water and the air or carbon dioxide gas with which it is impregnated does not render such water safe.

---

* As employed by Dr. Percy Frankland.

† See author's observations on this head in Rep., Chem. Ex., Madras, 1884.

CHAPTER IV.

AIR.

Composition of Air.

The atmosphere or air which surrounds the earth is a mixture of gases, consisting of 79 per cent. of nitrogen and 21 per cent. of oxygen by volume. It also contains normally a small amount (0·03 per cent.) of carbon dioxide gas, traces of ammonia and nitric acid, and a variable quantity of water in the form of vapour. The air gradually diminishes in density as we ascend from the surface of the earth, and it does not appear to extend beyond 200 miles from the surface.

The quantity of watery vapor which air is capable of containing varies with temperature and with barometric pressure. At the average pressure at sea-level and within the ranges of temperature met with in Madras, 1 cubic foot of air is capable of holding from 6 grains, at lowest temperature, to 12 grains, at highest, of watery vapour (14 to 28 grams per cubic meter). The amount of moisture which is most agreeable and generally best for health is about 60 per cent. of the quantity required for saturation of the air. This subject has to be further alluded to in the section on climate.

Nitrogen, of which the air is principally composed, possesses no active properties. Oxygen is essential for the support of animal life. Its main function is to oxidize (a process chemically analogous to burning) food substances which have been absorbed, and thus to evolve animal energy and heat. The proportion of oxygen in air varies a little in different places, being slightly less in towns than in the country. Traces of a condensed and very active form of oxygen, termed ozone, exist in very pure air, but not in the air of crowded places.

Carbon dioxide (carbonic acid gas) is given out abundantly in the respiration of animals, and it is absorbed by the green leaves of plants and decomposed by them under

the influence of light, the carbon being retained and oxygen liberated. The proportion of carbon dioxide varies to a small extent in pure air, but in crowded places it is considerably increased. This gas is evolved from lime-kilns, from the combustion of wood, coal, and organic matter generally, and from decaying organic matter. Men have been suffocated by it when incautiously sleeping near lime-kilns, or approaching places where large quantities of gunpowder had just been exploded in blasting, or after explosions in coal mines, or in descending into old wells and holds of ships.* Air containing much more than 5 per cent. of carbon dioxide will not support life, and 1·5 per cent. in air will cause head-ache.

Impurities of Air.

Natural air, like natural water, is never pure. It is being constantly polluted, but it is also constantly being purified by various agencies. Air is rendered impure by respiration, emanations from the skin and excretions of animals, by putrefaction of organic substances, by combustion, by exhalations from the soil, and by dust consisting of various mineral and organic materials. It is purified by the diffusion of gases, dispersion of impurities by wind, the action of plants, oxidation, rain and dew, and gravitation which causes the subsidence of dust in still air. The impurities of air may be considered in two classes: (1) gaseous, analogous to dissolved impurities in water; (2) suspended, like suspended impurities in water.

Of gaseous impurities excess of carbon dioxide has already been mentioned. Gases which are chemically poisonous or irritant are sometimes evolved from factories, such as brick-kilns and cement, alkali, smelting and various chemical works. Fetid organic gases, often of ammoniacal nature, emitted from putrefying materials, may exert poisonous effects. Gaseous impurities in air are rapidly diluted and rendered harmless by diffusion and dispersing currents of air. Those which are soluble in water are also carried down by rain, and complex organic gases are gradually oxidised or decomposed into simple compounds.

---

* A lighted candle may be used to test the purity of the air in such places before men enter them. If the flame be extinguished it is certain that the air will not support life.

Suspended solid impurities are everywhere present in air, and are, as a rule, much more dangerous, as well as more widely diffused than gaseous impurities.*

Mountain air and sea air are most free from them. They may be mineral or organic.

Mineral, or inorganic, suspended substances consist of dust raised by the wind or thrown up by volcanoes, minute crystals of common salt derived from sea spray, carbon from smoke, and particles of metals or other materials arising from certain trade processes. Dust has been known to be transported by wind for hundreds of miles, and it is believed that the dust thrown up in the great eruption of Krakatoa in 1883 was diffused through the entire atmosphere of the earth.†

Mineral dust in air is apt to cause diseases of the air passages and lungs (bronchitis, asthma, emphysema, and destructive lung diseases), and in trades, such as mining, and grinding metal implements, where much dust is produced, the average lifetime of workmen is shortened and lung diseases are more than usually prevalent. This is particularly the case when the particles of dust are hard and angular. The dust arising in certain trades may be chemically poisonous, for instance white-lead from paint-grinding, arsenic also from certain paints, antimony from printing type, &c.

Organic suspended matter in the air may be dead or living. The former, consisting of minute fragments of vegetable and animal tissues or dead microscopic animals or plants, cannot, unless in large quantity, be regarded as particularly dangerous in itself, but rather because it supplies food to such microbes as are capable of growing in air and is frequently accompanied by such microbes. Organic dust, however, if abundant, such as that arising in spinning factories, and in some places the pollen of flowers, causes irritation of the air passages and lungs.

Living suspended substances, like similar impurities in water, though usually harmless, are sometimes of a most dangerous and deadly nature. Microbes, which are the specific causes of certain diseases and putrefactive changes, may live and be transported in the air, and their spores or

---

* *Vide* Tyndall 'On Floating Matter in the Air."

† Report of Special Committee of Royal Society, 1888.

seeds, which have much greater vital resistance and are so extremely minute as to elude microscopic recognition, are still more likely to be so transported. As a matter of fact microbes and their spores are always present in the atmosphere, but they are particularly numerous in places where the soil is foul, where men or other animals are congregated, and where ventilation is bad. They subside rapidly in still air by gravitation.* Very few exist in mountain or sea air compared with the number found in the air of plains and of towns.†

Such organisms are drawn into the lungs with the inspired air, and thus the specific organisms of some diseases may enter the body; or they may be arrested in the nose or throat and be swallowed. Somewhat larger living bodies, such as fungi of various kinds, for example those which cause certain skin diseases, and the little insect which is the cause of itch, may not unfrequently be found floating in the air. The spores (seeds) of most fungi are extremely minute like those of the smaller microbes (bacteria). The rapid occurrence of fermentation or putrefaction (due to the development of microbes) in organic substances exposed to the air, and the growth of moulds (fungi) on such substances evidence the omnipresence of spores of these organisms in ordinary air.

Flying insects may act as carriers of disease. Contagious ophthalmia, anthrax, probably small-pox and several other diseases may be propagated by flies and perhaps mosquitoes. The latter also are believed to carry the blood filaria from man to water.

---

* Tyndall.

† Even only 1 per cubic meter may be found in mountain or ocean air. On the other hand M. Miguel found nearly 500 per cubic meter of air at Montsouris, and 3,500 in the air of a street in Paris, while no less than 97,000 per cubic meter existed in the air of a hospital ward. So far back as 1872 Surgeon D. Douglas Cunningham, M.B., made valuable microscopic researches on the air of Calcutta. (Appendix to 9th Report of Sanitary Commissioner with Government of India). His most important conclusions were : "Spores and other vegetable cells are constantly present in atmospheric dust, and usually occur in considerable numbers: the majority of them are living and capable of growth and development. No connection can be traced between the numbers of bacteria, spores, &c., present in the air and the occurrence of diarrhœa, dysentery, cholera, ague or dengue." The latter conclusion is against the value of the biological test as generally carried out, *i.e.*, by enumeration of the organisms irrespective of their nature.

Effects of Impure Air.

Diseases which are communicable through air are capable of being so communicated at very various distances, and some infections are transmitted much more readily than others; it appears as though many disease germs were incapable of living long in pure air and that the term of their vitality in air were limited for each disease. It is probable however that under favorable circumstances the spores of some of these organisms may retain their vitality in air for a great length of time. The infection of malaria, though produced in or upon the ground, is commonly transmitted through air. Other infections, which are readily transmissible through air, are those of the eruptive fevers (small-pox, measles, dengue, &c.), mumps, relapsing fever and whooping-cough. Those of cholera and enteric fever are less readily conveyed by air.

It is not often easy to ascertain the hurtful impurity in unwholesome air, for such air generally contains many kinds of impurity mingled. Thus air polluted by effluvia of decomposing animal matter often causes nausea or vomiting, loss of appetite, fever, with diarrhœa, and sometimes dysentery; but it is not generally certain whether these effects are due to chemically poisonous gases evolved or to certain microbes contained in the air, though the balance of opinion and of evidence is in favor of the latter cause.

The evil effects of overcrowding are, to a considerable extent, due to foul air. Oxygen is diminished and carbon dioxide largely increased in respired air, but the most noxious qualities of the air of crowded and ill-ventilated places are probably due to the poisonous organic effluvia exhaled from the lungs and the skin and to microbes contained in in such air. The immediate effect of breathing air rendered foul in this way is headache, sickness, loss of appetite, and a low feverish state—if it is habitually breathed general deterioration of health and increased liability to disease, especially to phthisis, are engendered.

Purification of Air—Ventilation—Cooling.

It is manifestly of the greatest importance that breathing-air should be as pure as possible. The great means for securing its purity is by constant removal and dispersion of impurities to facilitate their destruction by oxidation or

otherwise, and, at the same time, to provide a constant supply of fresh unpolluted air. This is the object of ventilation.

Subsidiary means are sometimes resorted to for the sake of destroying or getting rid of certain impurities: thus roads are watered to prevent dust in towns, wet-grinding has been largely substituted for dry-grinding in factories, smoke consuming furnaces are used to destroy smoke and noxious gases, the latter are sometimes condensed or dispersed high in the air by means of lofty chimneys, disease contagia are destroyed by chemical means or by heat; but ventilation is practically the sole means of purification for ordinary purposes of the air of dwelling houses.

Cleanliness is an important aid to ventilation in preserving the purity of air in houses. Microbes are comparatively few in the air of clean and of new rooms, while they abound in that of dirty and old rooms.*

In regard to ventilation we have to consider—firstly, the standard of purity which it is necessary to maintain in dwelling-rooms, and secondly, the means by which that standard may be maintained.

It is obvious that the air of inhabited places cannot be as pure as the external air; but it is assumed,† and indeed it has been ascertained by observation‡ that the sense of smell is generally a safe guide as to the purity of such air, and that if it does not differ perceptibly from the outside air the amount of impurity is not sufficient to influence the health of the inhabitants. Organic matter and fetid gases are the substances which affect the sense of smell, but carbon dioxide is generally taken as an indication of the amount of contamination of the air of inhabited places, because the quantity of this gas in air is easily determined by chemical tests.

It has been found experimentally that the air of inhabited rooms does not become sensibly "close" or unpleasant nor injurious to health when the amount of carbon dioxide remains below 0·08 per cent. 0·07 per cent. may therefore

---

* Carnelley: *Air of dwellings and schools and its relation to disease. Brit. Assoc.*, 1886.

† Parkes and de Chaumont.

‡ G. Wilson's *Hand-book of Hygiene*, 6th edition. Air containing less than 0·08 per cent. CO^2 was found to have no appreciable injurious effect.

be regarded as the largest amount of carbon dioxide allowable in the air of well-ventilated rooms.*

As each adult evolves about 0·6 cubic foot of carbon dioxide per hour, it may be calculated † that he will require a supply of at least 2,000 cubic feet of pure air per hour to maintain the air of his room in state of sufficient purity. At moderate work a man evolves twice as much impurity and requires double that supply of air. Sick people also require a much larger supply. It may therefore be laid down as a rule that the supply of air entering an inhabited room should never be less than 2,000 cubic feet per head per hour, that the supply to workshops should be 4,000 cubic feet, and that hospitals require at least as much. It is safest to make the same allowance for children as for adults in these calculations; and children require *proportionately* more air, as they do more food, than adults.

It is an important requisite of good ventilation that the quantity of air required should be supplied without any very perceptible draught; for this purpose considerable cubic space is needed. It has been found in practice that the air of a room cannot be changed oftener than from three to four times in an hour without creating much draught. Therefore for an hourly supply of 2,000 cubic feet of air a cubic space of not less than 500 feet per head is necessary, and a space of 660 feet or more is preferable. The best results in the practical ventilation of public buildings (schools) have been obtained with an air space of 1,000 cubic feet per head; a larger space appears to encourage stagnation of air.‡

A large space is also useful, because, in case of temporary failure of wind or other means of ventilation, it affords a reserve of air and becomes vitiated less rapidly than a small space.

Large rooms are more easily ventilated than small rooms,§ consequently in small rooms more numerous ventilating apertures and a larger cubic space per head should, if possible, be allowed.

---

* Parkes, de Chaumont, and many other authorities adopt 0·06 as the limit.

† The greatest allowable amount, less the percentage of carbon dioxide in ordinary air 0·07 — 0·04 = 0·03, and 0·6 cubic feet being evolved in one hour $\frac{0{\cdot}06 \times 100}{0{\cdot}03} = 2{,}000$. The amount of CO_2 in ordinary air is taken at 0·04 instead of 0·03 because in the air of towns the former may be nearer the truth.

‡ Carnelley.

§ Found so experimentally by G. Wilson,

A greater height than 12 or 14 feet is not generally found useful for the purposes of ventilation, and it is a good general rule that the superficial space (floor area) ought, in square measurement, to be not less than one-twelfth of the cubic space, in cube measurement.* Height is however of great service in keeping rooms cool in hot countries when the roof is strongly heated by the sun. Large superficial space is very useful in isolating individuals allowing the rapid diffusion of the exhalations from their lungs and skin. In hospitals it is obviously of particular advantage. We have seen that efficient ventilation cannot be provided without draught in a room affording less than 500 cubic feet per head of space, which must, therefore, be regarded as in all cases the smallest amount of cubic space which is compatible with purity of air in a dwelling-room. One-twelfth of 500 is 41·7, and, in round numbers, therefore 40 square feet per head must be regarded as the smallest superficial space allowable. 100 square feet is a good allowance, and less than this should not be permitted in hospitals.

The smallest effective size of ventilating openings is the next point to be considered. The size of the inlet openings should be at least 24 square inches (6 × 4 inches) per head and the outlet should be as large. This will allow 2,000 cubic feet per head per hour to enter and leave, supposing the air to flow through the openings at a rate of nearly 3½ feet per second, at which rate its motion is only slightly perceptible. It is impossible to obtain this constant rate of flow, except when artificial means of ventilation are employed; but under ordinary circumstances of climate in Southern India, when it is cold enough to have doors and windows closed, this minimum rate of ventilation will be secured by properly constructed apertures of the dimensions stated, and if doors and windows are closed to exclude hot air in the day time larger openings covered with wet grass mats should be provided.

It is necessary for good ventilation that the pure air which enters should be well distributed. If there be few openings and the air enters at considerable speed, most of it may pass in a stream from one opening to another without spreading throughout the room. To prevent this many openings for ventilation are generally required in large

* de Chaumont.

rooms, or the incoming air may be directed in such a way that it shall spread. To effect this purpose, a simple contrivance is to direct the entering air obliquely upwards by louvres or an inclined board at the ingress. Another plan to allow air to pass in through vertical tubes (Tobin's tubes) 4 feet or more high fixed in the corners or along the walls of the room. Direction upwards of the incoming current of air, besides serving to disperse it, also protects the inmates from draughts.

The difference in temperature of the air within a building, and of that outside, is an important factor in ventilation. In cold climates the air inside is nearly always warmer than the outer air; and as the air within expands with heat it becomes specifically lighter and ascends, being replaced by colder air which passes inwards most rapidly by the lowest openings in the building. The greater the difference in temperature inside and outside the building, and the higher the building, the more rapid is the ascending current. For this reason, in cold climates, it is generally practicable to provide some openings which serve constantly for the ingress, and others which serve constantly for the egress of air. In hot climates, however, the case is different, the outside air being sometimes colder and sometimes warmer than that inside, while sometimes the outside and inside temperatures are equal. Thus upward, downward or no currents may be produced by temperature, and as the difference of temperature is never very great the currents from this cause are never strong. We have then usually in India to depend upon the wind for natural ventilation, and it is manifest that unless revolving cowls or artificial ventilation be resorted to, the same openings must serve sometimes for ingress and sometimes for egress of air. The most simple and direct methods of ventilation are therefore the best; and tubes, shafts, and valves should, as a rule, be dispensed with. In single-storied buildings, with low roofs, ridge-ventilation may be all that is required. In higher buildings ventilators may be placed in doors or windows at a height of 6 or 7 feet, or separate ventilators may be placed in the walls. Direct ventilation at the ground level through the walls is generally to be deprecated, as foul air is more likely to be found near the ground than higher. In the huts of the poor, and even in the houses of the wealthy, there is often an insufficiency of windows for good ventilation even when they are open. Where this is found to be the case ventilators can, as a rule, be

inserted at a very small cost. Tiled roofs, even when no ridge ventilation is provided, generally afford a pretty free passage to air.

When, as occasionally happens, the wind fails entirely, and there is no difference of temperature outside and in to cause any movement of air, natural ventilation is impossible, and the air can be but slowly purified by the diffusion of gaseous and the subsidence of suspended impurities. In such circumstances doors and windows should be fully opened and people should, if possible, remain in the open air. The creation of movement by artificial means, as fans and punkahs, is particularly valuable under such circumstances.

Ventilation by shafts with revolving or fixed tops of various kinds is only efficient so long as the wind is pretty strong, that is when they are least wanted; but when the wind fails they cease to act as intended, and are less useful than ordinary direct openings. Such contrivances are therefore, as a rule, to be avoided for house ventilation.

Artificial ventilation may be carried out by (1) the extraction of foul air, pure air flowing in to take its place, and (2) the propulsion of pure air into the building, the foul air being thus forced out. Fan-wheels or pumps worked by steam or water power, or fires to heat the air in a high extraction chimney, are the means most frequently employed on the large scale for artificial ventilation of mines and large buildings, and they need only be mentioned here. Punkahs and thermantidotes must be more fully noticed.

Punkahs have a more important ventilating action than is generally supposed. They not only cause the rapid removal and dilution of expired air and air tainted by emanations from the skin, but each swing acts like the stroke of a piston in a box and forces air out of the openings at one side of a room, while fresh air enters by the openings at the other side owing to the slight rarefaction produced. This ventilating action is greatest and most useful when the air is stagnant. The cooling effect of a punkah is due to its causing a rapid change of air in contact with the skin, thus favoring evaporation of moisture from the skin, and also the abstraction of heat so long as the air is colder than the skin.

Thermantidotes are fan-wheels, usually driven by hand, used for propelling air into a room or house, the air being

cooled by passage through a wet mat made of *kus-kus* or other grass. They are of little use as cooling agents in damp climates, when the air is already nearly saturated; but in dry climates the air of houses may readily be cooled by them to the extent of 20° F. or even more.

The evaporation of water is a powerful means for cooling air. A quantity of water in evaporating absorbs as much heat as would raise four and-a-half times the quantity from freezing to boiling point. The evaporation of 1 gallon of water will reduce 26,000 cubic feet of air from 100° to 80° F. The effect of cooling and moistening air to a great extent by means of wind, or air from a thermantidote, flowing through wet mats is sometimes prejudicial to health on account of the sudden change and perhaps sometimes owing to the use of bad water. If such means be resorted to, care should be taken that the water employed be of good quality, and it is a wise precaution to add a little potassium permanganate to it.

Wet mats, besides cooling the air and increasing its moisture, act as filters, and remove a large proportion of the suspended impurities which it may contain. A similar, though lesser, effect is sometimes obtained by placing trays of water in ventilating openings, the incoming air being caused to impinge upon the surface of the water. The cleanliness of these trays and of the water requires frequent attention. In cold climates when the air has to be warmed, it is found more effectual to heat large quantities of air to a moderate degree (by means of large radiating surfaces, such as *gilled* stoves and pipes) than to heat small quantities more intensely. The same principle should be adopted in cooling the air: large surfaces of moderate cooling power being preferable to smaller ones of greater cooling power; for instance, large moderately damp mats are generally preferable to small well-wetted thermantidotes. More equable cooling is thus effected and draughts of very cold air are avoided.

Examination of Air and Ventilation.

The complete chemical, microscopic, and biological examinations of air are conducted on the same principles as similar examinations of water; but these, as well as exact measurements for artificial ventilation, must be left to skilled experts. The following easy scheme will, however, be found all that is generally needful and practicable :—

(1). Inspection of premises from outside to seek any possible cause of contamination of air entering a building, such as accumulations of decaying vegetable or animal matter, foul drains or latrines, slops thrown on ground, &c., in the vicinity of the doors, windows and other ventilating openings, or impurities lodged in the ventilating openings themselves.

(2). Inspection of interior of building to seek causes of contamination from within, such as dirt of floors and walls, accumulations of rubbish or dirty clothes, foul drains, sinks, bath-rooms, latrines, &c.

Local inspection is as necessary in the case of air-supply as in that of water-supply: in both cases dangerous impurities may otherwise escape detection, and in both cases the probability or the possibility of contamination must be guarded against.

(3). Examination of the sufficiency of ventilation of rooms under ordinary, or still better under *minimum*, conditions; for example, bed-rooms should be examined early in the morning after they have been occupied by the full number of inmates during the night, and in their usual condition of ventilation, before such doors and windows as are closed at night have been thrown open. For this examination the two following ready tests may be employed:—

Smell Test.—The inspector, after remaining for some time in pure open air, should rapidly enter the house or room and notice the odor, if any. If the air in the room does not differ sensibly from the outside air, the ventilation may be regarded as perfect. If otherwise, three degrees of impurity * may be discriminated: (1) close, (2) close and unpleasant, (3) very close and foul.

Lime-water Test.—Lime-water is made by shaking a quantity of fresh burnt lime with water in a stoppered bottle, the lime is allowed to subside, and the clear water is drawn off for use as required; it must be kept in a well-stoppered bottle. A clean dry bottle, preferably wide-mouthed, of nine ounces capacity, is filled with the air to be examined by pumping in the air with a small bellows or syringe.† Half an ounce of lime-water, carefully measured, is then

* de Chaumont.

† Or the ready method may be suggested of stuffing a clean bit of cloth several times into the bottle and withdrawing it.

poured into the bottle, which is to be stoppered or corked with a clean cork (protected with wax if it does not fit very tightly) and set aside after being well shaken. After the lapse of six hours the lime-water in the bottle should still be quite clear when shaken up. If turbid, it denotes that more than 0·07 per cent. of carbon dioxide was present in the air examined.

An eight-ounce bottle will usually be more easily obtainable, and may be used for this test with half a drachm less ($3\frac{1}{2}$ drachms instead of half an ounce) of lime-water.*

(4). *Measurement of Superficial Space.*—The floor area or superficies of a room is, for an ordinary rectangular room, its length multiplied by its breadth. If the room is irregular in shape, it can be measured in segments, and the areas of the different segments be added together. If the walls form straight lines the floor can always be divided into triangles, whatever the shape of the room. The area of a triangle is height $\times$ $\frac{1}{2}$ base. If the walls are curved the following data may be useful. Area of circle $= D^2 \times 0{\cdot}7854$ (D = diameter). Area of ellipse $= D \times d \times 0{\cdot}7854$. (D = long and d = short diameter). Area of segment of circle $= \frac{2hc}{3} + \frac{h^3}{2c}$ (h = height, c = chord). The superficial space of a room having been measured is divided by the number of occupants in order to obtain superficial space per head.

(5). *Measurement of Cubic Space.*—The floor area multiplied by the height of the room gives its cubic space or contents when the ceiling is flat. The following data will enable the contents of gabled or arched roofs to be calculated: contents of pyramid or cone = area of base $\times$ $\frac{1}{3}$ height; contents of dome = area of base $\times$ $\frac{2}{3}$ height. The cubic dimensions of projections, pillars, and large pieces of furniture should be measured separately and be deducted from the contents of the room. The contents thus corrected divided by the number of occupants gives the cubic air space per head.

(6). *Inlets, Outlets, and Distribution of Air.*—In ordinary natural ventilation the same opening will serve sometimes for ingress and sometimes for egress of air, according to variations of wind and temperature. The points to be noted are that the openings are sufficiently large, sufficiently numerous and, placed at sufficient intervals, to ensure not

---

* Vide *Air and Rain*, by Dr. Angus Smith.

only the entrance, but the equable distribution of a proper quantity of air, it being remembered that large rooms and those containing least obstruction, such as furniture, are more easily ventilated than small rooms crowded with furniture and require proportionately fewer openings. The distribution of the incoming air is usually tested by means of the smoke evolved from a smouldering rag held close to the apertures through which the air is entering. It may thus be observed whether the air is evenly distributed or passes in a stream from one aperture to another. Instead of the smoke-test a smell-test may be employed, any strongly smelling substance being placed at the apertures through which air is entering, and the distribution of the smell in different parts of the room being observed. The deflection of the flame of a candle or match held at any aperture will show whether air is flowing in or out through it, even when the current is too weak to be felt.

(7). *Arrangements for cooling, warming, or moistening the air* should be examined especially with reference to the purity and sufficiency of the air supplied. Two methods of cooling or keeping cool the air of houses are commonly practised: (1) cooling by evaporation of water, (2) shutting doors and windows to exclude radiant heat and hot air during the hottest part of the day. Cooling, dependant upon methods of construction of buildings, may also be examined under this head; details will be found in the chapter on houses.

CHAPTER V.

REMOVAL OF WASTE.

The constituents of the waste of human habitations are (1) latrine waste, comprising excrement, urine, and washing water; (2) kitchen waste, consisting of refuse portions of vegetable and animal food, washings of cooking vessels, and ashes; (3) house waste proper, general house sweepings and bath water; (4) stable waste, excreta of domestic animals and litter. In addition to these substances, towns have to remove factory waste and street sweepings. The refuse of slaughter-houses may be treated as latrine waste. All these substances have to be speedily removed and suitably disposed of in order to preserve the purity of soil and air in and about dwellings and to prevent contamination of water. Such removal and disposal is one of the most important duties of executive sanitary authorities and one upon which the health of towns especially depends.

Diarrhœa, febrile attacks, general ill-health and sore-throat are the most common and general results of exposure to emanations from foul sewers or accumulations of decaying organic matter.* Such emanations also undoubtedly increase the liability to, or actually convey the poisons of, specific diseases, such as cholera and enteric fever.

Liquid waste of all kinds, whether including urine and ordure or not, is termed *sewage*, and the channels by which it is removed are *sewers*. *Drains*, of which the primary use is to carry off water from the surface or from the depth of the ground, are occasionally used also for conveying sewage and thus serve a double purpose.

The *separate system* of drainage and sewerage provides for the removal of sewage in small well-made sewers, while storm water and drainage generally is carried off by large

* Albuminuria appears to result occasionally—*vide* cases reported by Dr. George Johnson in the British Medical Journal, 1888.

drains which need not be so carefully nor expensively constructed. The advantages of this system are that the *sewers* are very small and proportionately inexpensive; they are not so liable to be blocked because the quantity of sewage is tolerably constant and silt conveyed by storm water is excluded; the sewage is more highly concentrated and therefore more valuable as manure; while the *drains* need not be water-tight and will consequently be more efficient for sub-soil drainage.* The *combined system* of drainage and sewerage provides for the removal of drainage and sewage together in large sewer-drains which are expensive to build and maintain, while their large size is a disadvantage except during rain; they are likely to become blocked by deposits of mud and sand, and unless leaky they are of little or no use as sub-soil drains.

Solid waste, except such portion as passes off suspended in sewer water, has to be carted away. Excrement, except where water latrines are used, is included in solid waste, and in some places urine is carted away in separate vessels.

Systems of filth removal are commonly divided into (1) dry systems and (2) water-carriage or sewage systems. The advocates of either sometimes argue as if one of these systems alone could be adopted to the exclusion of the other. This, however, is impossible, and both systems must always co-exist in well-ordered towns and villages; foul water has to be got rid of by sewers, and dry rubbish must be carted away. The only question which can be at issue is whether ordure or urine, or both, should be removed by cartage or by sewerage. The principal arguments in favor of and against each practice may be briefly stated here.

In favor of a dry system of latrines, it may be contended that cleanliness and absence of effluvium is better ensured, diseased evacuations are isolated, diseases due to sewer emanations are prevented, a smaller supply of water is required, there is no waste of matters taken from the soil and valuable manure is saved, large and expensive sewage works are not required, foul water not containing latrine waste being removed in small sewers or being so inoffensive that it may be passed into ordinary drains, finally rivers and other sources of drinking water are preserved from dangerous contamination.

---

* This important advantage, especially in malarious places, is too commonly lost sight of.

On the other hand it may be urged that storage of excremental matters is objectionable and frequent removal is expensive, and that if dry earth be employed for deodorization, it is not easy to provide enough for use in large towns. This difficulty, however, would not exist if farms were worked by the local executive; the same earth can be used over and over again after drying, and the return latrine carts would carry earth instead of going empty.

In favor of the water-system of latrines it may be contended that it is the only means of securing *immediate* removal of excremental matter; if sewers be well constructed and thoroughly ventilated no dangerous effluvia arise; foul water has to be removed in any case, and it is often the least expensive and most convenient carrier of ordure; practically much excrement always finds its way into sewers, and English experience* proves that the sewage of towns in which the latrines are not connected with the sewers is not much purer than that of towns with water-closets.

Against the water-system may be stated the risk of fouling air, soil, and water and spreading disease by badly-made sewers, the necessity of a large and unfailing water-supply, the increased volume of sewage to be dealt with, the large cost of sewage works.

No one plan is universally applicable, and different systems of removal must be adopted in different places according to varying local circumstances and economic considerations, the one essential requirement in all good systems being the *speedy removal* of all waste organic substances before they have begun to decay.

Whatever method be employed, it must be remembered that the co-operation of all house-holders is necessary for the efficient working of any system, and the local sanitary authority should adopt every means for securing this co-operation. Successful cleansing depends largely upon systematic procedure, punctuality, and close attention to details—defects as often arise from faulty administration as from faulty system. The details of cleansing systems for large towns cannot be entered into here,† and large towns

---

* Frankland's Analyses.

† Mr. J. A. Jones' *Manual for District and Municipal Boards* may be consulted for much valuable information and practical detail on this subject.

can always command the advice of specialists. In the interest of the smaller towns and villages, however, some further remarks are desirable as to latrines, sewers, and disposal of waste.

Latrines.

The custom of the inhabitants of small villages to resort to the fields, with their lotahs for ablution, is excellent in principle; but they should prefer cultivated fields instead of waste ground, in order to save valuable manure and utilize the deodorant properties of tilled soil, and it would be an improvement to imitate the practice of the ancient Jews who buried their ordure.

The banks of tanks, streams, and canals near villages are almost invariably used as latrines, the water being convenient for ablution. Village authorities should be taught the danger of such pollution, its tendency to cause the spread of intestinal worms, dysentery, cholera, and some other diseases, and they should be responsible for its prevention.

Latrines, however, cannot ordinarily be dispensed with, whether for public or for household use. In villages, decency, cleanliness, deodorization, and utility would all be promoted by a simple plan of *moveable latrines;* shallow trenches, about 5½ inches wide,* being dug every afternoon and surrounded with a moveable wall of matting, the old trenches being filled in and the latrine moved to fresh ground every day or less frequently according to requirements. If villagers could once be induced to adopt this plan, they would probably appreciate its advantages and willingly retain it. Small latrines of this kind may also be advantageously used in private gardens when these are sufficiently large.

Large public latrines, such as have been built at considerable expense in many towns and villages, are inappropriate in most cases. There is a great tendency to construct a few such large latrines instead of many smaller ones in towns, because their primary cost is considered to be lower and their upkeep less troublesome; but the result is that they are often not used. Latrine accommodation,

* Wider trenches, such as are usually made and recommended, cannot be used without danger of falling bodily into them.

like water-supply, to be efficient must be *well distributed;* it is obviously unjust to punish people for passing ordure and urine on any piece of waste ground unless sufficiently numerous latrines and urinals are provided for their use. Very large latrines are generally only suitable for large aggregations of persons subject, in some measure, to discipline, such as bodies of troops, or workmen or prisoners.

The want of small towns and villages in this respect is not the provision of public latrines so much as attention to the condition and cleansing of the private latrines which exist, or should exist, in connection with all houses. Sick people, children, gosha women, and all persons at night, must have some place on the premises where they can relieve the calls of nature. The pollution of soil and air, which habitually goes on in the corners of courtyards set apart as latrines close to all ordinary dwellings, is as dangerous to health as it is disgusting to the senses.*

Latrines with impermeable floors properly drained into street sewers or into urine receptacles, as the case may be, and the frequent removal of excreta, deodorized, if possible, with dry earth or ashes, are essential for the healthiness of houses in most places. Cess-pits are never allowable. Water-latrines may come into use in towns provided with a large and constant supply of water, but they are not suitable to the circumstances of small towns and villages in most parts of India. The mcst suitable form of water-latrine would probably be a tank-latrine, the excreta falling into water in a cistern which could be emptied by a simple sluice or into a trough flushed periodically by a syphon-tank.†

Of the dry systems, dry earth ‡ for ordure is certainly the best, urine being preferably removed in a pail, or else allowed to flow into the sewers. The separation of ordure from urine and washing water may be effected by receiving the excreta upon an inclined floor which retains the solids while liquids are allowed to flow away. A small shovelful

---

* Such foul places may be found attached to nearly every house, not only to the houses of the poor. Kanny Lall Dey (*Hindu Social Laws and Habits*, Calcutta, 1866,) gave graphic descriptions of the rarely cleaned ash-pits, privies and cesspools, with adjoining wells and dirty bathing pools in houses of the wealthier classes. Such descriptions are still too frequently applicable.

† Mr. R. Field's automatic flush-tank.

‡ Strongly advocated by the Rev. Mr. Moule.

of dry earth should be thrown over the ordure by each person before leaving the latrine.

Urine rapidly decomposes and becomes offensive; it should therefore be, when possible, collected in air-tight receptacles, such as iron or tarred wood cylinders with funnel lids provided with curved tubes, the fluid retained in these serving to prevent escape of gas. Such cylinders may also be employed as separate urinals. Lime exerts a chemical action on urine and hastens its decomposition; hence this material should be avoided on the flooring and lower walls of latrines and urinals. Stone, tarred brick, tarred wood, glazed earthenware, asphalte or hydraulic cement may be used. Urine channels and collecting vessels and urinals should be daily scrubbed with a mop fixed to a handle to remove offensive deposits: simple flushing with water is not sufficient. Lumps of zinc chloride placed in urinals, so that the urine flows over them, are most effectual deodorants and last a considerable time.

The employment of water for ablution is no great obstacle to the separate removal of urine nor to the use of dry earth for deodorizing ordure. It adds less than one-third to the quantity of liquid to be removed, and dry earth is thrown over the ordure *after* ablution.

The quantity of ordure for a mixed Indian population is about 7½ oz. per head daily and of urine about 1¾ pints, or, including ablution water, about 2½ pints. The weight of dry earth required for deodorization is about three and a half times the weight of the excreta.* Ashes may also be used for the deodorization of ordure, and all kinds of household refuse may be thrown into dry latrines if they are cleaned out daily, or separate receptacles for such refuse may be provided. When dry earth cannot be employed, a *pail system* may be resorted to, pails or buckets being placed under the holes of latrines and receiving the mixed evacuations. Pails may be made of tarred wood or iron, and if they are carted away bodily after use, two sets must be provided; but it is waste of labor to remove pails which are only partly filled, and it is more economical to empty them at once into special covered soil-carts.

* Stanford. Mr. Faucus, of Alipur (quoted by Parkes) found 5 lb. of undried earth necessary for the fœces and 8 lb. for the urine of Hindu adults. Something depends upon the nature of the earth employed; fine mould is considered best.

Plate III.

Sewers and Latrines.

1. **Buchan's patent trap.** *a*, pipe leading from house; *b*, pipe leading to sewer; *c*, aperture for cleaning out deposit in trap: this may be covered with a grating and act as a gully for receiving waste water and to serve as a ventilator for the house pipe; *d*, ventilating shaft, which has been added in the figure in order to show the complete arrangements for house disconnection. This ventilator allows the escape of sewer gas and prevents it from forcing back the water in the trap and entering the house and also prevents the trap from being sucked dry by syphon-action when the pipe runs full. The ventilating pipe should be carried to the top of the house roof; or, at all events, it should open in a place where it cannot create a nuisance.

2. **Reynolds' trough-trap man-hole and ventilator.** *a*, at the house side, dips one inch or more, and *b*, at the sewer side, dips half an inch into the water of the trough. Care must be taken to fix this, and all other forms of water trap, in a perfectly horizontal position.

3. **Phillipson's patent trap.** This is an improvement on Buchan's, the cleaning aperture being placed at an angle, the bore being widened where the house-pipe enters and narrowed at the ascending portion (*a*), so as to produce a more rapid current there and flush out the trap more effectually.

4. **Phillipson's patent system of sewers.** These are examined and cleaned by *access pipes* placed at frequent intervals. The figure shows two plugs attached to flexible rods, and the portion of the sewer between them being tested with water to discover if there be any leakage.

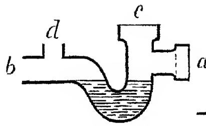
5. **Tub urinal** with air-tight cover, curved entrance tube at *a*, serving as a trap, and a small ventilator, filled with charcoal, being provided at *b*.

6. **Field's patent flushing-tank,** with annular syphon. When the water, which enters slowly by the pipe at the right, reaches the level of the top of the syphon, the tank is rapidly emptied through the syphon, the rush of water being useful for flushing sewers, latrines, etc. The frequency of flushing is regulated by regulating the flow of water into the tank.

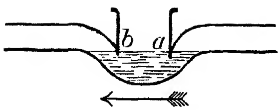
7. **Plan for private latrine** of Surgeon D. F. Dymott. Scale 9 feet = 1 inch. Above is a vertical section, showing *a* latrine, *b* drain, *c* compound (yard), *d* road. Below is a ground plan, showing *a* box for solid excreta, *b* pan for urine, etc., *c* dry-earth, *d* bath. Reproduced from Transact. S. I. Branch B.M.A., June 1888.

8. **Plan for public latrine.** A ground plan, showing latrine, urine tank and semi-circular spaces for dry-earth storage or for washing. B section through openings, showing slanting slabs for standing upon. C section from front to back showing floor slanting towards openings, slope on which excreta fall, and urine drain, with low-level roadway for latrine carts and sweepers. The surface to receive excreta is too much inclined, as shown, if it be desired that solids should remain upon it. This arrangement need only be slightly modified for a pail-system, in which movable pails would be placed under the openings. A long trough under the openings and some arrangement for periodical flushing would convert it into a suitable water-latrine. An estimate for a *double* latrine of this kind (back to back with road for carts between), prepared for the author by Mr. A. C. Cotterill, C.E., in Egypt, some years ago, amounted to £18, then equivalent to Rs. 200. The cost in India ought not to be more, except the additional cost of stone instead of tarred-wood for slabs and supports in places where whiteants are common.

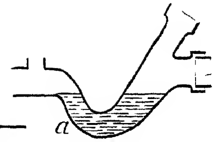
Plate III



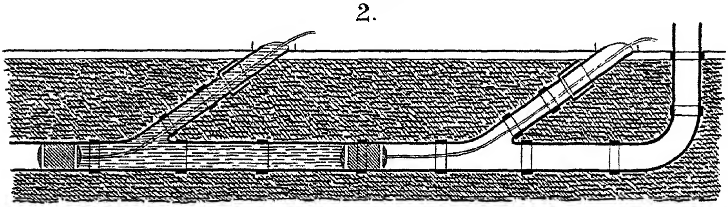
1.



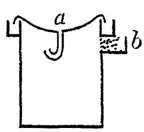
2.



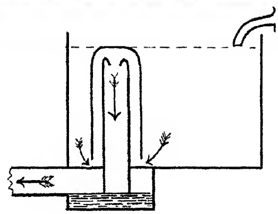
3.



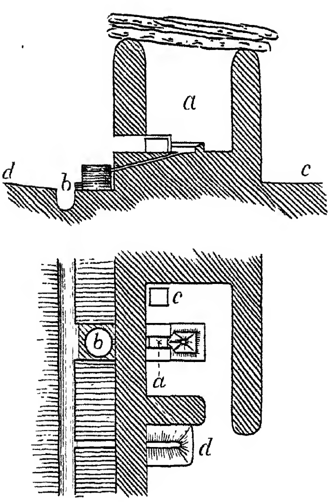
4.



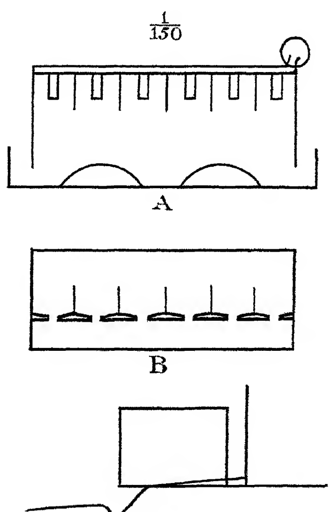
5.



6.



7.



C

8.

The best time for cleansing latrines is in the morning soon after they have been used, and if emptied out at this time the least possible nuisance will be created even if little or no earth be used for deodorization; but well covered carts or pails should always be employed for the removal of excrement.

Covered Sewers and Sewer-drains.

The subject of sewage is unsavoury and distasteful; this is one reason for the tendency to put everything connected with it out of sight. The ignoring and hiding of filth have led to innumerable sanitary evils: * disease and death too surely teach that it is a most foul and dangerous practice to conceal and store instead of removing and utilising it. Cesspools and large ash-pits are now condemned by all sound sanitarians, but the use of underground sewers cannot be avoided in crowded and level towns where there is not space nor sufficient inclination of the ground for open ones. The well-made underground sewer of the present day is, however, very different from the ill-constructed, leaky, unventilated sewer of the past, which was often no better than a cess-pit. Certain points have now been recognized as essential for good sewerage; these are briefly, firm foundations, proper gradients, correct size and shape, junctions in direction of flow, direct lines and wide curves, smooth surface, "imperviousness of material, free aëration, and facility of inspection at all points;" † in fact they must be made as nearly as possible like good open sewers.

Sewer pipes leading from houses may be best made of glazed earthenware ‡ well jointed with cement or asphalte and 4 inches in diameter. The smaller street-sewers are best made of similar larger pipes and the larger street-sewers of well-burnt or vitrified bricks set in and lined with hydraulic cement, the lower part being formed of "invert blocks;" the best sectional shape transversely is

* For the influence of sewerage in improving the health of towns, see a paper by Mr. E. F. Smith of Michigan abstracted in *Indian Medical Gazette*, September 1886; also Parkes' *Hygiene*, 7th edition, p. 120.

† Sir R. Rawlinson.

‡ There ought to be a great future for Indian pottery manufacture in this direction. The excellent stoneware produced by the Madras School of Arts proves that such work can be done locally; water, drainage, and sewage pipes and open channels of this imperishable material would no doubt find a large and increasing local market.

ovoid with the smaller end downwards. The fall of house-pipes should be considerable,* and that of street or main sewers 1 in 300 to 1 in 700 according to size, the smaller ones requiring the greater fall. The best rate of flow for sewage is about 3 feet per second. Ventilators and openings for cleaning must be provided at frequent intervals and especially at curves and junctions.

House-pipes should not be connected directly with the main sewers; water-valves or "traps" with ventilating openings should always be interposed in order to prevent the entrance of sewer air into the houses.

Leakages in sewer-pipes may be detected by several methods of testing. The water test consists in completely blocking the lower part of the pipe and filling it with water from above; if the water does not sink it shows that the pipe is water-tight. The smoke test consists in blowing smoke in at one end of the pipe; the smoke finds its way out through any leaks. The smell test consists in pouring any strongly smelling liquid into the pipe; it may be smelt wherever there is a leak.†

Open Sewers and Sewer-drains.

Open sewers and sewer-drains are preferable to covered ones for the following reasons: there is no pent-up sewer-gas; inspection is easy at all parts, and obstructions can be at once removed; no traps, valves, ventilators, &c., are required; rats and other vermin are not harboured and are not so likely to do damage; less water is required as deposits can be at once removed, and flushing is easy; the primary cost and the expense of maintenance are much less. On the other hand, large space is required for open sewers, and they can only be made in places where the slope of the surface is considerable: in flat places where the sewers are long, sufficient fall can be obtained only by cutting them so deep that they form inconvenient and dangerous ditches.‡ Sewer-drains would be best placed in a lane behind the backyards of houses or in the centre of wide streets.

---

* At least 1 in 48 according to Dr. Corfield.

† In well-jointed sewers leakages may occur from sinking of foundations or the growth of roots. Eassie states that the penetration of roots may be prevented by a coating of tar which causes them to turn away.

‡ *Vide Drainage of Calcutta*, by W. Clark, 1871. It may be suggested that the use of *Shone ejectors* at intervals would obviate this difficulty.

The old brick sewer-drains which still exist by the road sides in many streets of Madras are good examples of what such channels ought *not* to be. Their angular shape, roughness and want of fall render them hopelessly foul, and their leakiness keeps the soil in a constant state of dampness and pollution.

The best shape for open sewer-drains is a cutting with sloping banks and a glazed earthenware or brick lined with cement U-shaped sewer at its bottom, the sides of the cutting being paved or even left unpaved. The U-shaped sewer need only be large enough to carry off the ordinary sewage, while the drain should be of sufficient size to carry off all storm water in wet weather. Channels of this kind would be suitable for the sewerage and drainage of most villages.

Disposal of Sewage.

Return to land as manure is the proper destination of all organic waste, and disposal of it in this way is best, not only from a sanitary but also from an economical point of view. The liquid sewage of many European towns is thus utilised, and the returns from the sewage farms by the sale of stock and produce are sufficient to pay a large part of the cost of scavenging.*

Certain objections have been urged against sewage farming; thus it has been said to create a nuisance and breed disease in the vicinity, to produce crops which are unwholesome, to sodden the land, to be inapplicable in wet weather. All these objections have been practically proved to be invalid in the case of well-managed farms.† Sand or other barren and valueless land can thus be made highly productive. Sewage irrigation is specially applicable to dry waste land in India, water and manure being supplied together. Where the fall is insufficient, the sewage must be

* For instance, in Birmingham over £20,000 a year is realised—*vide* Dr. A. Hill, Soc. Med. Officers of Health, 1886. In Madras, sewage is profitably employed on several small farms—*vide* Mr. Jones' *Manual and Municipal Reports.*

† The sewage farms of Berlin, Breslau, and Dantzig are, owing to good sub-soil drainage, actually drier in rainy weather than many of the neighbouring estates. Letter from Berlin by Alexander Aird in *Morning Post*, 18th April 1888.

Sir R. Rawlinson (College of State Medicine, June 1888) states that land in England will absorb yearly 100 inches vertical of sewage. In India land ought generally to be capable of taking much more.

pumped up by steam, bullock, or hand power to a sufficient height for it to be distributed over the land by gravitation. For distributing the sewage evenly, the land may be laid out in small flats, or in slopes, or in broad ridges and furrows (30 feet from crest to crest), the sewage being flowed on from channels running along the intervening ridges. When applied to growing crops it is sometimes a better plan to have narrow ridges and furrows, the plants growing on the ridges and the sewage flowing in the furrows so as to avoid its direct contact with the plants. Damp lands or small farms which receive a very large proportionate quantity of sewage should be drained by sub-soil drains, 6 feet deep; the effluent water from such drains is tolerably pure.

The quantity of land required for sewage irrigation depends a good deal on its quality. One acre of porous land will suffice for the sewage of from 300 to 500 persons in a wet climate and for more than double that number in a dry climate like Madras. Intermittency of application is essential for the efficiency of sewage irrigation. The land must therefore be divided into plots, the sewage being flowed over each in succession for a certain number of hours. This interruption is necessary in order to allow air to penetrate the ground, so that oxygen may be supplied for the oxidation of organic matter.

Sewage mixed with earth is speedily rendered harmless and inodorous by the absorptive power of the soil, by chemical combinations between some of its constituents and those of the soil, and by oxidation. This oxidation occurs mainly in the surface soil to a depth of a foot or a foot and a-half.*

The principal crop hitherto grown under sewage irrigation in India has been Hariali grass. Good returns could no doubt be obtained from the cultivation of Guinea grass as a green fodder crop and from that of many other plants.

Disposal of Dry Latrine Waste and Organic Refuse.

Immediate utilization on land is also the best method of disposing of these matters. Their accumulation and storage

* Warington. Micro-organisms in the soil are the active agents in determining such oxidation. Certain micro-organisms have an opposite or reducing power. Nitrogenous organic matters are oxidised into nitrates and thus become available as plant-food.

in the form of dung hills is improper from a sanitary point of view. The best plan is to bury them daily in shallow trenches, the ground being soon after ploughed and cropped. A modification of this plan may be suggested: to lay the refuse in deep furrows cut with a large plough, the soil being afterwards turned over it by the same plough. Even if no crop were grown at once the same land might be used again after a short interval. Urine may with advantage be applied in the furrows between plants grown on ridges.*

Disposal of Dust, Mud and Inorganic Refuse.

Dry rubbish of all kinds, when it does not contain much vegetable or animal matter, may be most usefully employed for filling up hollows and foul wells and tanks, but it should always be covered over with earth half a foot or more in depth.† Else it may be burnt, the ashes being mixed with night-soil and sold or employed as manure.

Disposal of Dead Bodies.

The bodies of animals which are not used as food, or which have died from the effects of non-infectious disease, should be disposed of in the same manner as other organic refuse. The bodies of animals which have died from infectious diseases should be destroyed by burning or by burial in quick lime, in order that the microbes which are the causes of such diseases may be got rid of.

Human bodies are disposed of according to the dictates of custom, convenience, and religion. Cremation, burial, exposure (as by Parsis) and casting bodies into rivers are the methods followed in India. Cremation, properly carried out, is quite unobjectionable; it is best performed in specially-made covered furnaces. Burial is also a good method if the graves be deep, far apart, and placed at a distance from any source of water or habitation. Quickly-growing trees, such as *casuarina*, may with advantage be

---

* When dry refuse is sold as manure to different farmers, nuisance is much more likely to arise than when local bodies deal with it themselves. In the Punjab in 1885, Rs. 84,621 was obtained by the sale of manure. In the same year the city of Glasgow realised £13,700 from this source after paying more than £10,000 for its carriage by railway.

† For further information upon this and many other points connected with removal of waste, Mr. Jones' *Manual* may be consulted.

planted in burial-grounds. Exposure of bodies and casting them into rivers are customs which are both offensive and dangerous, especially in populous places.

Attention is much required to prevent or correct some very prevalent malpractices with regard to cremation and burial. Both cremation and burial grounds should be far from any dwelling or water-supply. Imperfect cremation is very objectionable, and a proper supply of fuel should always be provided. It would be best, in large villages and towns, always to employ furnaces. In the case of burial, shallow graves should not be permitted:* they ought to be fully 6 feet deep. A custom which is little better than that of throwing dead bodies into rivers is that of burying them in river-beds during the dry season. Tanks and wells in burial grounds are very dangerous, as, even if not habitually used for drinking, the water may be so used.

Dead bodies, especially those of persons who have died from infectious diseases, should not be kept long in houses, but be cremated or buried as soon as possible. Those which are likely to spread infection or have become offensive should be completely wrapped up in a cloth saturated with some disinfectant † before removal.

---

* In Egypt the author has noticed a practice of *burial above ground*, a tomb being built up of mud and the body simply deposited in it. During the cholera epidemic of 1883, a well situated in a large over-crowded grave-yard containing such tombs was largely used for drinking purposes, the water being reputed holy. Cholera and enteric fever were very fatal in this place.

† One part of corrosive sublimate in 1,000 of water is one of the best. A strong solution of zinc chloride or of carbolic acid may also be used for this purpose.

CHAPTER VI.

LOCAL CONDITIONS: SOIL, CLIMATE, AND METEOROLOGY.

I. Soil.

Constituents of Soil.

Soils consist of a great variety of mineral matters generally mixed near the surface, and sometimes to a great depth, with some vegetable and animal substances, and containing more or less air and water. Dense non-porous rocks, such as granite, quartz, and limestone, are the only constituents of soils which never contain organic matter, air or water.

The mineral constituents, which form the great bulk of soils, differ greatly with regard to their state of aggregation, as influencing the porosity and dryness of the soil, and their solubility, as influencing the impurity of well and spring water.

The organic matter contained in soil may be regarded in the same light as organic impurity in air and in water. It may be animal or vegetable, living or dead. The dead organic matter consists principally of decomposing remains of plants and of the dead bodies and excrements of animals, large and small. Dead organic substances may occur as fragments mixed with the inorganic particles of the soil, or as products of the decomposition of such substances, for instance humic and ulmic acids, or as filmy incrustations upon the inorganic particles. Soils, such as sand, gravel, or disintegrated gneiss, which seem to be very free from organic matter, often contain a considerable quantity in the latter form. The author has noticed in such soils in the Deccan particles of quartz and other stone from which the organic incrustation could be peeled off almost like the

skin of a peach,* and particles of sand so incrusted can be recognised under the microscope. Such soils are often malarious in damp weather; nothing could favor the growth of micro-organisms better than these organic films. The living organic matter in soil consists of burrowing animals, worms, larvæ, eggs (perhaps of parasites), ants and other insects, and microscopic animals of simpler structure, and, besides the larger vegetable organisms, of *fungi* and *bacteria*, which are probably the most important of all the impurities of soil. Microbes exist principally in the surface soil. Damp porous soils, rich in decaying organic matter, are those in which they flourish most, and such soils are notoriously the most unhealthy. It is held by some authorities † that the microbes which cause certain diseases breed and multiply in the soil, and there is good ground for this belief in several cases. Under the influence of microbe growth in the surface soil, organic matter becomes decomposed and oxidized. Nitrogenous organic matter yielding ammonia is oxidized to nitric acid. Large quantities of nitre (potassium nitrate) are hence found in the polluted soil of old towns, the potash being supplied by wood ashes and vegetable refuse; the extensive deposits of nitre which exist in many parts of India are believed to mark the sites of ancient centres of population.

Organic matter is generally found most abundantly in the surface soil; but sometimes it is deposited in the deeper layers; for instance, when a porous soil, such as sand or gravel, rests upon an impervious layer of clay or hard rock, a large amount of organic deposit may exist in the lowest portion of the porous soil, being matter carried down by the water which percolates through the soil.‡

Air in Soil.

Air contained in soil is very impure as it is mixed with the gaseous products of decomposition of organic and

---

* This is probably formed by the detritus of luxuriant *ramnah* grass which covers this part of the country at one season and is only partly harvested.

† Especially Professor VonPettenkofer of Munich. This view is probably correct with regard to *Anthrax bacillus*, but has not been proved with regard to others.

‡ Such a deposit exists under the sand at Bagshot in England and contaminates the well-water.

inorganic constituents of the soil, and may also convey floating microbes and their seeds. It is generally highly charged with carbon dioxide gas especially in the deeper layers of porous soils which contain much organic matter. It is important that such impure ground air should be prevented from rising within houses by rendering their basements impermeable. It is also important that the flow of air into and out of the soil should be limited as much as possible. Such a flow is promoted by (1) differences of temperature between the soil and the upper air; if the soil be warmer there will be exhalation from it and *vice versâ*; trees and herbage are useful in preserving equable temperature of the ground; (2) differences in level of sub-soil water; water rising in or permeating the soil must displace air; (3) permeability of the surface; paving or other means which render the surface more or less impermeable, even herbage, have great influence in lessening ground exhalations. The poison of malaria is certainly contained in such exhalations, and probably the poisons of some other diseases may be thus conveyed.

Water in Soil.

More or less *moisture* exists in all soils, except the most compact rocks. Some soils, such as heavy clays, are very tenaceous of moisture, while others, such as pure sands, are easily dried. Moisture does not as a rule fill up all the spaces between the particles of soil, but merely forms a coating upon these particles, or is absorbed by organic matter in the soil, or exists in a loose state of combination with some mineral substances. In damp soils the contained air is saturated with watery vapour. Moisture in soil is an essential factor of decomposition and promotes the growth of animal and vegetable life including that of the numerous micro-organisms which may exist in the ground. Moisture is necessary for the development of malaria, and dampness of soil is one of the most important and common of the causes which render certain localities less healthy than others. Not only malarious diseases, but scrofula including phthisis,* rheumatic and intestinal diseases are much more prevalent in damp localities than elsewhere. Numerous instances

* Buchanan's well-known researches. Reps. M.O. Privy Council, 1866-67.

are known where an increase of dampness produced by irrigation works or by obstruction to drainage * has resulted in a great increase of sickness and mortality from malarial fevers, and it is well known that in many places the prevalence of such fevers may be measured and foretold by the rainfall.†

Sub-soil water is the term usually applied to water which fills all the interspaces in a porous soil. It flows, more or less slowly, through the lower layers of such a soil where it rests upon impermeable rock or clay. This is the first water which is tapped on digging a hole in the ground and furnishes the supply of shallow wells. The depth of sub-soil water from the surface of the ground varies much in different places and at different seasons; in some localities, with considerable inclination, it may all run off rapidly after rain, and none may be found in dry seasons. Sub-soil water influences the moisture of the ground and of the air above it as well as the amount of ground-air. When it is only a few feet or less from the surface, the ground above must always be damp. When sub-soil water rises it displaces a proportionate quantity of ground-air, and when it falls more air enters the ground, which is left moist and in a condition to favor decomposition and the growth of microbes. It is therefore apparent that, where the level of sub-soil water can be regulated, it should be kept (1) as low as possible and (2) at a constant level.

Healthy and Unhealthy Soils.

The geological and chemical characters of soil affect its healthiness in so far as they influence the conformation and material of its surface, the vegetation which it supports, the amount and nature of dust and other impurities which it yields to the air, its permeability by air and water, its capacity for retaining water on the surface or in the sub-soil, and the impurities which it yields to water.

---

* The cases of the Ganges and Jumna irrigation canals, silting up of channels in Burdwan, and on a smaller scale at Kambam (*vide* Mr. Farmer's Rep.) may be mentioned as examples.

† Professor Celli has prepared statistics which show that rainfall is the only meteorological condition which influences the prevalence of malaria in Rome. The fact is so well established in India that it is unnecessary to give examples. Fever occurs after the rain has had time to penetrate the soil and encourage decomposition and microbic growth.

When the surface is considerably inclined, a soil is more likely to be dry than when it is level, as a large proportion of rain runs off without sinking into the ground, and the deeper strata are also likely to be inclined and to promote deep drainage. For this reason hills are well-drained and their soil is comparatively dry although more rain falls upon them than upon adjacent plains. The soil of valleys and plains at the foot of hills is generally very moist and rich in organic matter derived from the remains of plants washed down from the hills as well as from the local luxuriance of vegetable and animal life. Impurities emanating from the soil are apt to accumulate in the often motionless air of sheltered valleys.

An impermeable surface, such as one of granite, trap, slate or limestone rock, is very dry unless there are cavities which retain water. A less impervious surface formed of dense clay, although it does not allow water to pass through it very readily, is very retentive of moisture and is damp unless drained artificially. Pervious soils, formed of gravel, sand, light clay or sand-stone, are generally very healthy if dry, that is, if the drainage be unobstructed and the level of sub-soil water be low and not subject to great fluctuation. Such soils, however, may be malarious during light rain or soon after heavy rain. Water-logged soils and marshes in which the sub-soil water is close to the surface are unhealthy and often malarious. Alluvial soils, deposited by rivers, and found also in the beds of tanks and in deep valleys and other hollows, consist of clay and sand mixed with a large proportion of vegetable matter; they are usually unhealthy owing to their dampness, their level flatness impeding drainage, and to the impurity which they communicate to water. Soils of this kind are greatly improved by drainage and by measures which render their surface less permeable. Hollows and irregular water-courses, where decaying vegetable matter accumulates, are sometimes local causes of unhealthiness which can generally be rectified.

Made soils, consisting of sweepings and dry rubbish of all kinds from towns are very unhealthy, but improve in course of time, especially if well drained.* The soil

* Parkes and Burdon Saunderson made an investigation of this subject at Liverpool in 1871 and concluded that house refuse takes about three years to decay, but "is virtually innocuous before that time."

of marshes is frequently, but not invariably, malarious. Peaty marshes are non-malarious, and in Australia non-malarious marshes are found.*

Reflection and absorption of heat and light depend a good deal upon the dryness and color of the surface. A bare light-colored soil may reflect light so strongly as to be injurious to the eyes and brain. Dry sand and rocks form the hottest surfaces; damp clays and surfaces clothed with vegetation, the coolest.

The influence of vegetation is very important. Short herbage and trees are generally healthy, while brush-wood and rank herbage are deleterious. Trees keep the surface of the ground cool by protecting it from the sun, thus diminishing exhalation from the soil; they promote dryness of the soil and coolness of air in damp places by taking up moisture from their roots and evaporating it on the great extent of surface afforded by their leaves, the amount of water so evaporated being much greater than that which would pass off from the surface of the ground shaded by the trees; they feed upon matters which pollute the soil and the air and thus act as purifying agents. They may act injuriously by obstructing movement of air and drainage of soil and increasing moisture of air; but belts of trees may also be useful to protect from malaria drifted by the wind. Brush-wood is generally bad; it adds to the organic impurity on the surface and obstructs the passage of air, the oxidation of surface impurities and the growth of herbage, while it keeps he surface damp and may promote the growth of *fungi* and other injurious organisms. Long rank herbage may act in a similar way. Short herbage, however, is always beneficial; it keeps the surface cool, promotes evaporation, lessens exhalation and dust, feeds on impurities.

Dry cultivation, for similar reasons, improves the healthiness of a locality. Regular tillage appears to be always beneficial, though excavation or any disturbance of malarious soil which has long lain fallow is likely to engender fever. Wet cultivation, however, is not, as a rule, favorable

---

* This may be due either to some peculiarity of soil which is unfavorable to the development of malaria or to the non-importation of germs of malaria-causing organisms. Parkes attributed it to some peculiarities of the vegetation.

to health, but it is probably more so than allowing damp lands to remain uncultivated.*

Improvement of Unhealthy Soils.

Few individuals can select their place of residence, and existing centres of population cannot be moved to healthier sites. The sanitary question in relation to soil, therefore, usually resolves itself into the improvement of present sites.

Dampness and the presence of decaying organic matter in the soil or on its surface are the two principal causes of unhealthiness. The former may be mitigated by drainage, the latter by oxidation and vegetation. Drainage may be distinguished into that of the surface and that of the sub-soil. Surface drainage provides for the carrying off of rain-water (with some surface impurities) instead of allowing it to sink into the soil. Sub-soil drainage provides, by means of deep or underground channels, for the removal of water contained in the soil or for lowering the level of sub-soil water. Sub-soil drains are usually made by loosely jointed or perforated earthenware pipes or even a layer of large stones in deep channels which are then covered in with earth. Large channels for sub-soil drainage are usually open. The removal of obstructions in natural drainage channels is often sufficient to cause a marked improvement in the dryness and healthiness of a place.†

Oxidation of organic matter in the soil is promoted by free access of air and by drainage which allows air to permeate the soil. The removal of brush-wood and regular tillage are most important aids.

Sanitary and engineering authorities are all agreed that irrigation without drainage has a most evil influence upon health, and that deep drainage improves the soil as well as the health of the inhabitants. The efficiency of drainage should especially be looked to in irrigated lands. In most parts of Madras the natural drainage is good, but in some parts of Northern India flat tracts of sedimentary

---

* In Italy rice cultivation is believed to be productive of fever (Professor Celli informs me that it is invariably so) and is not allowed close to towns (*vide* Parkes' *Practical Hygiene*, 7th edition). In India, however, it is certain that rice lands are not the most malarious soils. They appear to be more fully flooded in India, and malaria may thus be occluded in a way pointed out by Tommasi-Crudeli.

† The ancient Romans fully recognised the importance of dryness of soil. Old and now silted-up sub-soil drains are to be found under the remains of their houses and in the country about Rome. The latter were also apparently used for collecting water in wells.

soil occur where irrigation water has no sufficient outflows, and in such places malaria prevails to an alarming extent. For instance in 1885, in the town of Sunpat on the Delhi branch of the Jumna canal there were 833 deaths from fever in a population of 13,077, a rate of 62·93 per 1,000 per annum.*

The good influence of cultivation and of the growth of herbage and trees have been already noticed. Works for the improvement of malarious soils, by the removal of brushwood, drainage, and cultivation, are certain to be attended with an increased production of malaria when the soil is *first* turned up. Such works should, therefore, be undertaken at the time of year when fever is least prevalent in the locality.

If for any reason improvement of an unhealthy damp soil by drainage and cultivation is impracticable, a considerable degree of improvement may be attained by other measures, such as raising the level of the ground by cartage of soil from a distance, rendering the surface more or less impervious by pavement or other means, or covering an unhealthy area of land with a sheet of water.

The management of irrigation is a most important matter. If an increased volume of water be poured into a district, the channels, natural or artificial, which were previously sufficient for its drainage, may prove insufficient; a general stagnation and rise of sub-soil water and greatly increased unhealthiness may result. Hence when irrigation is resorted to, drainage should receive especial attention.

Wet cultivation should not be encouraged in the immediate vicinity of houses; but it is probable that damp, undrained malarious soils are more unhealthy if left uncultivated than when subjected to wet cultivation, and it is generally impracticable to arrest the irrigation (and thus the food supply and revenue) of large tracts of land round towns and villages.

II. Climate.†

Climate is generally understood to mean local characters and changes of the air with regard to temperature, moisture,

---

* *Evils of Canal Irrigation and their Prevention*, by T. H. Thornton, C.S.I., Journal Society of Arts, March 1888.

† *Climates and Weather of India*, by H. F. Blandford, F.R.S., Lond., 1889, is a new and excellent work which should be consulted for local information.

pressure, wind, cloud, rain, purity, electric state, as well as local amount and intensity of the sun's heat and light. In considering the effect upon health of residence in any particular place, all other local conditions have also to be taken into account. That climatic conditions have a very pronounced effect upon health is proved by the geographical distribution of diseases, and still more so by their seasonal prevalence. Some knowledge of physiography* is necessary in order to fully understand all the phenomena of climate, and the influence exerted by relative proportion of land and water, hot or cold winds and ocean currents, mountains, altitude, character of the surface, and other local conditions which are of secondary importance only to latitude in determining those phenomena.

Temperature.

Temperature affords the most usual basis for the classification of climates, and the simplest division is into hot, temperate, and cold. This applies to the mean annual temperature. But in places with the same mean temperature the extreme fluctuations may be very great or very small. In islands and on the sea coast the difference between the hottest and coldest seasons is least marked and such a climate is termed equable. On the other hand, the climate of regions far inland is extreme, being very cold in winter and very hot in summer.† Besides annual fluctuations both daily and irregular fluctuations also occur; in constant climates such fluctuations are small, while in inconstant or variable climates they are great, there being much difference between the day and night temperatures or frequent, sudden, unseasonable changes. Inland and temperate climates are generally the most variable, hot island and coast climates the most constant.

Temperature has an important influence upon health. Variable temperate climates and climates subject to extreme differences between the hot and cold seasons are those which produce the most vigorous races of mankind; this is probably due to natural selection, for weakly people are

---

* Huxley's *Physiography* may be consulted.

† As an example it may be mentioned that the difference between the mean temperature of the hottest and that of the coldest month in Madras is only 12° F., while in Peshawar the difference is 39° F.

constantly killed by great changes of temperature. Constant and equable climates on the other hand, especially when hot, moist, and well supplied with food, tend to produce a weakly and languid race of men. The prevalence of particular diseases is much affected by temperature; in cold and changeable climates diseases of the lungs are very prevalent and fatal and rheumatism is frequent, while in hot climates diseases of the bowels and liver and malarial fevers are more common. Some diseases, such as malarious fevers and cholera, are arrested by cold; and high temperature, combined with dryness, arrests plague and is unfavorable to other diseases. Exposure to the direct heat of the sun in hot climates sometimes produces an intense form of fever (*sun-fever*) which is speedily fatal or else ends in recovery within a few days. Heat apoplexy is more frequently caused by very high temperature in the shade than by exposure to the sun; it is very rare except in persons who are in bad health or of intemperate habits.

Moisture.

The quantity of watery vapour which air is capable of containing increases rapidly with rise of temperature. For instance at freezing-point it can contain only 2 grains of moisture per cubic foot, while at 70°F. it can contain 8 grains. Therefore air which is saturated with watery vapour or exceedingly damp at a low temperature becomes relatively very dry when its temperature is much raised, although the absolute quantity of moisture contained in it remains the same. The absolute quantity of moisture contained in air is therefore much less important than the quantity in relation to temperature. The latter is usually expressed as percentage of the quantity required for saturation at the given temperature. Thus air at a temperature of 70° F. containing 4 grains of aqueous vapour per cubic foot would be said to have a humidity of 50 per cent.

From this it will be understood how air which is relatively dry at a high temperature becomes moistened and even saturated as its temperature is lowered. If the temperature be lowered below the point of saturation (*dew-point*), the excess of moisture is deposited in the form of water, as dew, rain, cloud, mist. Hence the dampness of cool evening air and the deposit of dew on cold surfaces. On the other hand when the temperature of saturated air is raised, it becomes relatively dry and capable of taking up

more moisture, and the hotter it becomes, the more does it encourage evaporation.

Temperature therefore has great influence upon the moisture of the air, so also have large bodies of water and the nature of the surface. Mountains, as the Western Ghâts during the south-west monsoon, deprive winds passing over them of much moisture and cool them, but render the climate more variable at the other side by removing vapour from the air. The presence of aqueous vapour in the air, even when not deposited in the form of cloud, obstructs the passage of heat.* Thus in places where the air is damp the heat of the sun is slightly moderated, but rapid radiation of heat from the ground is considerably prevented, the climate being thus rendered equable. Dryness of the air, on the contrary, favors great solar heat in the day-time and rapid radiation from the ground, causing comparatively hot days and cold nights. Moisture further tends to produce equability of climate by the cooling effect of evaporation when the air is heated and by the liberation of latent heat when vapour is condensed as the air cools.

Moist climates are, other things being equal, undoubtedly less healthy than dry ones. Many reasons may be assigned for this. Moisture of air and of soil generally go together, and the evil effects of moisture of soil have been already noticed. Micro-organisms multiply more readily and are more abundant in moist than in dry air. Moisture is an essential factor in the production of malaria and of putrefaction. Evaporation from the skin and lungs and capacity for exertion are lessened by moisture of air.

The mean annual moisture of air on the coasts of India is about 70, and in the Deccan and dry parts of Northern India about 55 per cent. of saturation quantity. On the coast the range is small, about 20; in the interior it varies from 30 to 50.

Pressure.

The pressure of air at the sea-level is equal to that of about 760 millimeters (30 inches) of mercury, or about 34 feet of water, or a weight of 15 pounds on every square inch of surface. As we ascend above the level of the sea this

* Aqueous vapour obstructs the heat of the sun much less than that radiated from the ground. Tyndall.

pressure diminishes; thus at Bangalore it is equal to that of 27·7 inches of mercury, and at Ootacamund of only $23\frac{1}{2}$ inches. The effect of diminished pressure is to cause expansion of the air and to encourage evaporation. The small changes of pressure observed in any one place can have no perceptible effect upon health. The physiological effect of considerably diminished pressure is to increase the rapidity of the respiration and the pulse; but no injurious effect is produced upon previously healthy persons by a diminution of pressure such as occurs up to an altitude of 9,000 feet above the sea.

In considering the effect of high altitudes above the sea-level upon climate and upon health, other factors, besides diminished atmospheric pressure, have to be taken into account. Thus the temperature becomes lower as we ascend,* radiation of heat being much increased by the lessened thickness of air and greatly lessened amount of aqueous vapour through which it has to pass. The air of high regions is often very dry owing to good drainage of the ground, rapid evaporation and free movement of air. Increased purity of air is one of the factors of healthiness in such places; impurities of all kinds, including micro-organisms, rapidly diminish as we ascend. Well-drained soil, pure air, pure water, lower temperature, and often increased exercise, are, more probably than any effect of diminished air pressure, the real causes of healthiness in hill climates.

Wind.

Stagnation of air greatly favors the accumulation of all kinds of impurities in it and lessens the rapidity of oxidation. Constant movement of air is therefore beneficial. Such movement, and indeed wind generally, is caused by alterations of temperature. Wind may perhaps in some cases transport the material of disease. It certainly does so for some distance in the case of malaria. The good effect of wind in dispersing and destroying organic impurities is, however, far more predominant than any injurious effect. The temperature and moisture of the wind, depending upon the surface over which it has blown, has often a very marked influence upon the climate of a locality. Though moderate movement of the air is beneficial, violent movement is not so. High winds, especially if cold, are

* Glaisher found the diminution to be about 4° F. for every inch of fall in barometer.

likely, by chilling the skin, to excite congestion of internal organs, and they may increase the impurity of air by raising dust. Exposure to winds which are known to be malarious should be avoided; protection from their evil effects may sometimes be obtained by the intervention of a plantation of trees or of a broad sheet of water.

Cloud.

When moisture-laden air becomes cooled (to below the dew-point) from any cause, such as meeting a current of colder air, cloud or mist results, or large drops of rain may be formed. Clouds thus denote a super-saturated condition of the air in which they exist. The air near the ground may, however, be dry, while clouds exist higher up. The effect of clouds is to promote coolness of climate by arresting heat from the sun and equability by arresting radiation of heat from the earth. They may exert an unfavorable influence by interfering with light which is required for the health of plants and animals.

Rain.

Rain is beneficial by washing impurities from the air and supplying necessary water, besides cooling the air. Heavy rain washes impurities from the surface of the ground into the soil and into water-courses, and is unfavorable to the production of malaria during its continuance. Light rain encourages decomposition of substances upon and in the soil, the growth of microbes, and the production of malaria. Therefore in places with a heavy rainfall we find fever most prevalent some time after rain, and in places with a light rainfall it prevails during the rains. The effect of rain upon moisture of air and soil is obvious. There is often a remarkable contrast between the amounts of rain which fall in one place at different seasons of the year, and the total amount at different places also shows extreme contrasts.

Purity of air has been already discussed in the Chapter on Air. Little is known regarding the influence of electric conditions of the air upon health.

The Sun

is the cause, directly or remotely, of all energy upon the earth. This energy is transmitted in the first place as

radiant heat and light. Green plants especially, and most animals to a lesser degree, require heat and light for their development. Green plants under the influence of light decompose carbon dioxide gas which is evolved by animals and by the decomposition of organic substances. The direct heat of the sun* is useful in promoting dryness of the surface and probably in destroying micro-organisms, as well as in causing currents of air. Moderate exposure to it is beneficial to men in cool climates and is not necessarily detrimental to their health in hot climates.† Light, however, is much more necessary and conducive to health than heat, though its mode of action on animals is not well understood. A part of the good effect attributed to it is, no doubt, due to the usually coincident good ventilation and often out-door exercise. Excessive light, as reflection from a light-colored soil or from snow, is very prejudicial to the eyes, and through them may even affect the brain.

III.—Meteorology

is the science of observation of climatic phenomena. In the reports on the Meteorology of India ‡ observations of the following points are recorded, being collected from numerous observatories in every part of India:—

1. Solar radiation and duration of bright sunshine.
2. Nocturnal radiation and temperature of the ground.
3. Temperature of the air.
4. Atmospheric pressure.
5. Wind direction and movement.
6. Hygrometry.
7. Cloud proportion.
8. Rainfall.

Temperature of solar radiation is a measure of the direct heat of the sun. The solar radiation thermometer is a self-registering mercurial thermometer, having the bulb and half an inch of the stem coated with lamp-black, and it is enclosed in a large glass tube from which the air is exhausted. The bulb is blackened to render it more absorbent of heat, and the outer tube serves to protect it from currents of air.

---

* Sometimes marking a temperature of 170° F. or even more.

† In hot climates indeed the most vigorous and hardy people have a good deal of such exposure. The Arabs and Persians speak with contempt of "shade-nurtured" weaklings.

‡ By Mr. Blandford—*vide* Report for 1886.

This thermometer is easily affected by surrounding objects. It is corrected by comparison with an arbitrary standard instrument.

The duration of bright sunshine is measured in a few places by the sunshine-recorder,* which consists of a spherical glass lens having a curved brass plate fixed beneath it at such a distance that the focal point in which the sun's rays converge travels across the surface of the plate between sunrise and sunset. A slip of card, with printed divisions corresponding to hours, is inserted in grooves on the plate, so that when the sun shines brightly a line is burnt on it; measurement of this line gives the time of bright sunshine.

Nocturnal radiation from the ground is measured by a minimum self-registering spirit thermometer laid on a thick pad of common country blanket, which affords a more uniform radiating surface than grass or bare ground. The temperature of the ground at various depths is observed at only a few stations.

The temperature of the air is observed in most places only twice daily, at 10 A.M. and 4 P.M., by means of an ordinary mercurial thermometer (the dry-bulb of the *dry and wet bulbs*). These readings, together with those of the maximum and minimum thermometers, afford the data for the deduction of the mean temperature. The highest and lowest temperature of the air in the shade is recorded by means of a mercurial self-registering maximum and a spirit self-registering minimum thermometer, the indices of which must be set daily after reading. These thermometers are kept in a cage fixed to one of the supports of a thatched shed, open all round, the bulbs of the thermometers being 4 to 4½ feet above the ground.

The atmospheric pressure is measured by a mercurial barometer.†

The barometers are kept in masonry buildings to protect them as much as possible from changes of temperature. The mean pressure is determined from two (sometimes three or four) daily readings, in some cases corrected by results of

* Invented by Mr. Campbell and improved by Professor G. Stokes.
† Most of those in use are on Fortin's principle.

hourly observations in former years. The corrections of the readings for temperature, &c., are made in the central offices.

Wind.—The direction is observed at 10 A.M. and 4 P.M. The anemometer reading shows the amount of wind in miles.

Hygrometry.—The moisture of the air is calculated from the difference between the readings of the dry and wet bulb thermometers at 10 A.M. and 4 P.M. and by the *minimum* dry and wet bulb readings. These instruments must be freely exposed to the wind in the thermometer shed. Not only humidity but altitude and temperature of air influence the temperature of evaporation (wet bulb).

Cloud is estimated in the usual way by looking all round, overcast sky being noted as 10 and cloudless sky as 0. Observations are made at 10 A.M. and 4 P.M.

Rain is generally measured at 6 P.M.

The method of using Meteorological Instruments

must be learned practically at a meteorological observatory or a physical laboratory. Full descriptions of these instruments would therefore be superfluous in this place.* The principle only of the most important instruments will be briefly explained.

The barometer is a balance for weighing the pressure of the air. Mercury is used because it is the heaviest known liquid. When a long tube, closed at one end, is filled with mercury and its open end is inverted in a cup or cistern full of mercury, the pressure of the air on the surface of the mercury in the cup keeps the mercury in the tube pressed up to a height of about 30 inches, supposing the experiment to be performed at the sea-level. As we ascend above the sea-level, the weight of the air above us, and consequently the height of mercury in the barometer tube, becomes less and less. Therefore the barometer may be used for ascertaining the height of any place above the level of the sea. The following table shows the number of feet ascended

---

* Those who desire full information may consult King's *Manual*, or Parkes' *Practical Hygiene*, or Scott's *Instructions in the use of Meteorological Instruments*, or *The Indian Meteorologist's Vade-Mecum.*

for each inch fall of the mercury from 30 inches to 22 inches :—

Inches of mercury.	29	28	27	26	25	24	23	22
Height in feet for every inch.	886	918	951	986	1,025	1,068	1,113	1,161
Total height ...	886	1,804	2,755	3,741	4,766	5,834	6,947	8,108

The fluctuations of the barometer in one place indicate changes in the density of the atmosphere above. These are mainly due to variations of temperature and moisture and air, currents, which may occur in the upper regions of the air as well as near the surface of the ground.

The aneroid barometer is a very portable instrument. Its indications depend upon the contraction or expansion, under the influence of atmosphere pressure, of an elastic metal box from which the air has been partly exhausted. It is regulated by comparison with a mercurial barometer.

Thermometers are instruments for measuring the intensity of heat. The expansion of mercury is commonly employed for the purpose, mercury being selected because it is affected by small quantities of heat and expands equably at different temperatures.

The maximum thermometer is provided with an index which is pushed up by the column of mercury and remains at the highest point reached.

The minimum thermometer is made with alcohol instead of mercury, and contains an index which is drawn down by the alcohol to the lowest point reached and is not pressed up by the ascending alcohol.

The wet bulb thermometer has its bulb constantly kept wet by an envelope of cotton cloth in communication with a cup containing water. This thermometer therefore gives the temperature produced by evaporation, and as water in evaporating absorbs heat, it must always indicate a lower temperature than the dry bulb thermometer except when the air is saturated with moisture and no evaporation can take place. Other conditions being unchanged, the drier the air the greater will be the difference between the indications of the wet and dry bulb thermometers. The rapidity of

evaporation is increased not only by dryness of air, but also by increase of temperature and diminution of pressure, conditions which have to be taken into account in calculating the moisture of the air from dry and wet bulb thermometer readings.

The rain gauge is an instrument for measuring the rainfall. It consists of a carefully made funnel of exact calculated size at the rim and a measuring vessel in which the water is collected.* A commonly used size for the funnel is 4·697 inches in diameter; $\frac{1}{10}$ inch of rain falling into this gives 1 fluid ounce of water.

The anemometer is a self-recording instrument which shows the amount of wind. It consists essentially of a horizontal wheel with four spokes, each of which bears at its extremity a half-spherical cup. The pressure of the wind on the concave surface of such a cup is one-fourth more than on the convex surface.

* The square area of the circular aperture may be easily calculated ($d^2 \times 0·7854$), and conversely we may calculate the size of circle equivalent to any given square surface.

CHAPTER VII.

HOUSES.

GOOD health largely depends upon the healthiness of the houses in which people sleep and also spend a portion of the day. The two great causes of unhealthiness in houses are *damp* and *dirt*. Dirt is here taken in its most comprehensive sense as including foulness of soil, dust, rags and refuse in and about the house, and foulness of air from contamination by such dust and refuse, deficient ventilation, latrine, sewer, or ground emanations and other causes.

Damp and dirt, especially when they co-exist, greatly encourage the growth of microbes and even of large *fungi*; it is a matter of common observation that circumstances which favor such growth are unfavorable to health even if the microbes present be not themselves specific causes of disease. Damp, dirt, and over-crowding not only encourage the spread of epidemic and all communicable diseases, but foster other diseases and produce a general low state of health by interfering with the physiological functions of the body, particularly those of the lungs and skin. The demolition and reconstruction of unhealthy houses has been attended with excellent results in many towns.* For instance in Glasgow "it was proved by special investigation that the people whose wretched houses were demolished by the Improvement Trust distributed themselves over the city. It is often said that the habits of these people are such that, go where they please, they will not be the better of the change. It is evident, however, that they found physical conditions so much more conducive to health that,

* The English Public Health Act provides for the demolition or improvement of unhealthy and erection of healthy houses. Such provisions are also included in the *City of Madras Municipal Act*, 1884, and in the *Madras District Municipalities Act*, 1884, and provision for cleansing and draining unwholesome buildings and lands in the *Madras Local Boards Act*, 1884.

whether or not their habits have been improved, undoubtedly their health has been, in their new residences." * Demolition or improvement of insanitary dwellings in one direction is of little use, however, if the erection of similar dwellings in other directions is not prohibited. "If these places, which hardly anything short of clearance will remedy, are not to grow worse, and if other localities like them are not to spring into existence, building regulations which will effectually prevent huts and houses being built irrespective of ventilation, drainage, air-space, and means of scavengering must be enforced. . . . In Calcutta, though considerable sums are being spent in endeavouring to improve unhealthy localities, equally unhealthy areas are arising."† In towns the effective control of building operations is comparatively easy, but in villages, it is more difficult; the diffusion of hygienic education will do much to assist such control. No town can be very healthy or well-ordered where sanitary building regulations do not exist or are not enforced.‡

The subjects cf water-supply, drainage, sewage and ventilation, all of which require attention in connection with houses, have been already treated of; but a few points regarding them may usefully be noted here. A supply of good water, if not delivered in the house, should be available within a reasonable distance. If the soil be permeable and damp, deep sub-soil drainage of the site should, if possible, be provided. In any case surface drainage should be attended to, and the surface should be rendered as impermeable as possible. Water and slops should not be thrown upon the ground, but be removed by proper drains. A syphon trap and ventilator should be provided between any sewer pipe leading from a house and its connection with the main sewer; the ventilator should be so placed that gases escaping from it may not enter the house—a ventilating pipe carried up to the top of the roof may be used. The latrine should be a separate building, or be placed against the outer wall of the house, with good separate ventilation and no direct passage into the house;

---

* *Vital Statistics of Glasgow*, by J. B. Russell, M.D., LL.D.

† Report by Dr. Simpson, Medical Officer of Health. *Indian Medical Gazette*, January 1887.

‡ On this subject No. IV, *Model Bye-laws for Sanitary Authorities*, of the English Local Government Board (London; Knight and Co.) may be consulted.

it may be connected with the house by a covered passage open at the sides. The lighting and ventilation of each room should be separately arranged for; the superficial and cubic space to be provided (*vide* Chapter on Air) must be sufficient for the number of occupants; in addition to the windows and doors which can be closed, unclosable openings should exist sufficient for minimum ventilation. Doors, windows, and other openings should, if possible, be placed so as not to face the direction from which an unhealthy wind or rain may come.

Preparation of Site.

High, dry, sloping ground is the best, whether the soil be permeable or not. As a rule, however, the site of a house is not a matter of selection, and it has to be built where ground is available. If the soil be permeable, and particularly if it be damp, deep sub-soil drainage should be resorted to. If this cannot be done, the level may be raised by bringing clean earth or sand from another place. For small houses or huts a platform of loose stones may be made. Brushwood should be removed, hollows filled up, and surface drainage provided for.

The Ground Floor

should be raised above the level of the ground outside so as to facilitate cleaning and promote dryness. It should be water and air tight in order to exclude damp and exhalations from the soil. For mud huts, a thick flooring of well-puddled mud may be used. A coating of hydraulic cement should, if possible, be laid over this. If this is not done, special care should be taken to build on a high, dry platform and to make the floor as high as possible above the ground. In very damp places, wooden or bamboo huts* may, with advantage, be raised above the ground on piles, and large houses may be built on platforms raised on open brick or stone arches. The basement floor of large houses is best made of a thick layer of concrete.

Walls

are intended to exclude damp, great heat, great cold; the most suitable materials and method of construction

* As in some parts of Burmah.

will therefore largely depend upon climate; but the materials employed by the great majority of the population must be the least expensive and most readily obtainable. Mud is employed everywhere and sun-dried or even burnt bricks or stone bedded in mud or mortar, wood, and bamboo matting, plain, tarred, or plastered with mud, are used in various parts of the country. Impermeable materials are generally the best for walls* because they effectually exclude damp from rain beating on them, do not soak it up from the ground and do not absorb organic matter from air. To prevent damp rising from the ground in brick and mud walls, a *damp-proof course* should be inserted in the lower part of the walls. This is best made continuous with the damp-proof layer of the floor, and may be made of tarred brick, which would be a very cheap material for mud huts, or of hydraulic cement, impermeable stone set in cement, asphalte, or vitrified tiles. A damp-proof course may be inserted in an existing wall without pulling it down.† Double walls are effective in excluding damp, heat and cold; the space between should be ventilated. For temporary or movable huts, bamboo-matting is an excellent material; it is very light, and can be rendered air-tight or water-tight by plastering with mud or tarring or covering with tarred cloth. When plain, it provides excellent ventilation; nothing could be better for temporary or even permanent hospitals in hot climates; when dirty it can be washed, or burnt and replaced.‡ For the outside of walls, plaster or lime-wash is often used, but this can have no particular hygienic effect. Hydraulic cement is good for excluding damp.

For the interior a coating of some smooth impermeable material, which is non-absorbent and can be easily cleaned, is best. § This cannot commonly be provided however.

---

* This is the general opinion. Mr. Eassie (*Healthy Houses*) prefers permeable material, such as brick. He compares impermeable walls to water-proof garments and objects to them principally on the score of their retaining damp. Good ventilation should prevent this, as it does with ventilated water-proof garments.

† A damp-proof course would also afford some protection against white-ants.

‡ It has been in use for some years in the contagious wards of the Madras General Hospital.

§ Care must be taken not to use paint containing arsenic or other poisonous material. Arsenic occurs most commonly in green colors, and many cases of slow poisoning from their use have been recorded.

Mud walls may be left plain or be whitewashed from time to time with fresh-burnt lime. The common fashion of plastering walls and floors with cow-dung and water is decidedly to be condemned; it renders them damp, affords material for the propagation of micro-organisms, and pollutes the air.

Upper Floors

are commonly made of wood and lower floors are occasionally. The space, if any, between such a floor and the ceiling of the lower rooms, or between a floor and the impermeable ground covering, should be ventilated by several openings; but it is better, especially in hot climates, when such spaces are particularly likely to harbour dirt and vermin, to avoid them altogether in building. Thus the use of even ceiling cloths is to be deprecated: the joists and boards of the upper floor should form the ceiling of the rooms below. Brick or concrete arches between iron girders form an excellent ceiling and flooring.

Roofs

being designed to keep out rain and heat, while it is an advantage for them to permit some passage of air, are constructed in various ways, depending to a great extent upon the climate and the materials available. When the materials do not permit the passage of air, ridge-ventilation ought to be provided. Roofs made of thatch, or other materials which harbour insects and other vermin, may usefully be lined inside with tarred paper or matting.

For protecting against the heat of the sun the principal devices are thickness and non-conductibility of material, height,* light color externally, and double roofs.

Rain water which falls on a roof should be carried off by channel pipes fixed to the eaves or else be received on a paved surface and be carried away by surface drains, so that it may not soak into the ground close to the walls.

---

* In accordance with a well-known physical law, the heat radiated from a roof is inversely as the square of its distance. Therefore the direct heat reaching a person from a roof 5 feet above him is four times as much as would reach him if the roof were 10 feet above him.

Verandahs

are of great use in hot and wet countries to protect the side-walls of a house from solar heat and from beating rain. They are also very useful as well-ventilated day-rooms and as sleeping places in sultry weather when the air is stagnant and ventilation fails within doors.

Out-houses and Stables

require as much attention as regular houses in order to preserve the health of persons residing in or near them and that of animals in them. Dryness, ventilation, good water-supply, drainage to remove urine and dirty water, and regular cleansing must all be looked to.

Public Buildings

especially schools, hospitals and barracks, where persons are congregated in considerable numbers, require great attention to hygienic arrangements. Ample ventilation and water-supply is particularly necessary for hospitals. Hospitals and barracks however are generally well looked after, but schools are often completely neglected.* This is a matter which requires special attention, not only with reference to the present health of children and the prevention of epidemics, but because "the child is the father of the man;" bad physical development tells throughout life, and insanitary habits acquired in childhood are with difficulty rectified. The hygienic condition of schools therefore in every respect deserves the greatest care. School-rooms should be so arranged that students do not face the glare from windows: the desks should be lighted from behind or above, and the shape and size of seats, benches and desks should be such as to secure comfort and easy position for children of different sizes.†

---

* Surgeon-General Bidie some time ago urged attention to the bad condition of schools with regard to latrine accommodation, ventilation, &c.

† In 1886-87 in all India 3,343,544 pupils attended 127,116 schools and colleges: the great importance of school hygiene may be inferred.

CHAPTER VIII.

PERSONAL HYGIENE.

So many matters related to health are in the power of individuals themselves and of heads of families that this division of the subject is of wider practical importance than any other. Some of these matters have been already treated of; but any approach to a full discussion of all is here impossible. Other chapters must be referred to for much that is individually applicable: in this place only a few of the more salient points connected with personal hygiene can be alluded to.

Habit.

The persistence of acquired habits is a remarkable and controlling character of all organisms. Habits, however caused, are most easily originated in early life, become confirmed by practice (though the influence of the original cause may have been withdrawn), and are potent for good or evil upon individuals, communities, and posterity. The acquirement of good habits is, therefore, of supreme importance to all individuals as affecting the health and happiness of themselves, their neighbours, and their children.

It is especially with regard to the physical and mental training of children that the influence of habit can be most productive of good and most avertive of evil; the firm implanting of healthy habits and the eradication of unhealthy ones is the highest duty of parents and teachers. For the inculcation of hygienic habits some knowledge of hygiene is needful, but the most fruitful method of teaching them is by example in their practice. Hence parents and teachers should endeavour themselves to teach by practice, and should remember that the influence of a well-disciplined school or household and well-trained companions upon children has a most potent and abiding good effect.

It is difficult to break acquired habits, but the oftener they are broken, the more easy is it to destroy them; in the

eradication of unhealthy habits as in the acquirement of healthy ones, the difficulty is half surmounted when the first effort has been made. As some guide towards the formation of healthy habits, the following points may be indicated: personal cleanliness; household cleanliness; regularity and punctuality; temperance in food, drink, sleep, sexual indulgence; mental and physical exercise, but avoidance of mental worry and great corporal fatigue; care in obtaining pure drinking water, wholesome food, and fresh air. Constant anxiety with regard to health is, however, a state of mind to be deprecated, and is not at all needed for the acquirement and practice of healthy habits; indeed it is often a consequence of ill health and insanitary habits.

Custom

has much power not only in the formation of social habits, but in the preservation of certain habits which are known and acknowledged to be bad. People do as their neighbours do, and even seem to think as their neighbours are believed to think, because they do not wish to appear singular. They would rather endure discomfort and possibly disease than face the scorn of custom or the pointing finger of ridicule. Those who would repeal the unwritten but binding laws of custom, when they clash with the laws of health, must sometimes brave both scorn and ridicule in the first place; but they will earn a certain reward from health and ultimately be accorded the respect and gratitude of weaker or more ignorant fellow-men.

The reform of evil social customs and the training of children in good sanitary habits greatly depend upon the sound general and hygienic education of women, and any advance in this direction is to be hailed as a good presage by sanitarians. Not only the progress of household and personal hygiene, but the success attending public sanitation in any community must be in a large measure due to its wives and mothers, the presiding spirits of its houses and the trainers of its children.

It may be useful to only mention a few of many noxious customs which education and good sense should reform. Such are intemperance, including eating to excess at festivals and entertainments; pollution of water which is used for drinking, by ablution of the person and of clothes in it and in other ways; too early and infant marriages; insanitary practices as to abstention from food, air, and

cleanliness connected with parturient women and new-born children; suckling children after they have teeth and can run about; deficient exercise for women; funeral entertainments; various superstitious practices commou to ignorant persons of all religions, such as shutting up the rooms of sick people to keep out evil spirits, prayer and charm healing with neglect of sanitary measures for infectious and other diseases, drinking foul water from holy places.

Cleanliness

in its most comprehensive sense embraces nearly all sanitation. Cleanliness of food, air, water, soil, and dwellings has been already noticed; a few lines must here be devoted to cleanliness of person.

Cleaning of the skin is particularly necessary in hot climates when the amount of watery sweat and solid excretion and desquamation from it is considerable, the skin performing a part of the function which belongs to the kidneys and lungs in colder climates. The effect of dirt and retained excretion upon the skin is to interfere with its action, prevent the contact of air which oxidises noxious impurities, and favor the production or propagation of some skin diseases. Most persons go through the form of washing their bodies daily with water, but the cleansing effect of such ablution is often very small. Unless soap, or some substitute for it, be employed, water, especially hard water, does not readily carry off the dirt, which is usually more or less greasy, from the skin. Friction of the skin during ablution, and with a towel or cloth afterwards, greatly assists cleansing. The very imperfect way in which ablution is usually performed is shown by the extensive prevalence of itch, ring-worm, and other skin affections, and the frequent occurrence of lice, fleas, and bugs on the body and clothing. Want of attention to the cleanliness of the genital organs is a frequent cause of irritation and sometimes of disease. All parts where hair grows require special care in cleaning.

The employment of dirty water for washing is one cause of uncleanness and disease. Clean water, soap, and friction are the three requisites for cleaning the skin properly.

The practice of oil-inunction after bathing, as often used by the well-to-do, is specially beneficial to thin and aged persons.

Frequent cleaning of the mouth and teeth is a healthy custom, and serves to preserve the teeth and to get rid of remains of food and secretions which may decompose in the mouth. It is very important, however, that only the purest water, such as is used for drinking, should be employed for this purpose.

Cleanliness of clothing is a necessary accompaniment of cleanliness of skin. Frequent washing of inner garments is requisite. Clothes should be washed in clean water, and it is very desirable that the clothes belonging to different persons, or at all events those belonging to different families, should be kept separate, in order to prevent communication of disease. Skin diseases and small-pox are probably often communicated by clothes. The building and regulation of pubic washing-places would do much to promote cleanliness and prevent infection of clothing.

Clothing.

The principal object of clothing is to afford protection against heat and cold. Man, with his bare, sensitive, and porous skin requires such protection to enable him to bear extremes and vicissitudes of heat and cold, drought and damp. In cold and changeable climates clothing cannot be dispensed with; in warm and equable ones it is less necessary. The skin of persons accustomed to out-door exposure becomes thicker, harder, and less sensitive—consequently less in need of clothing—than that of persons who live more in houses, are generally more fully clad, and undergo less exposure.

The very young and very old are more sensitive to changes of temperature and more liable to suffer from congestions or inflammations in consequence of chills than are persons in middle life; young and old people therefore need especial care with regard to clothing. Young children in India are often much neglected in this way.

The secondary purposes of decency and ornament for which clothing is employed are of less hygienic importance. Ideas of decency and ornament vary much among different people; questions of taste do not concern us here: but when people distort and bind themselves injuriously, in obedience to the dictates of senseless fashions and false ideals of beauty and grace, it becomes the duty of sanitarians and sensible persons to protest and interfere.

Although Indian women have not, with rare exceptions, adopted the rigid corsets and high-heeled narrow boots which disfigure many of their European sisters, nor the scantiness of their evening dress, yet undue constriction of the waist is sometimes practised by them. Tight girdles or stays in children and adolescents impede the expansion and natural development of the chest, lungs, and heart, and injure general nutrition by interfering with the purification and circulation of the blood. Constriction of the waist is probably the most common cause of displacements of the womb which are a frequent source of suffering and illhealth to fashionable women. Abdominal viscera also suffer; dyspepsia, constipation, or intestinal irritation may be sometimes due to tight lacing.*

The common practice of sleeping with a sheet or blanket drawn over the face is objectionable, because exhalations from the skin or possibly dirty clothes are thus inhaled. It may perhaps be of advantage in some places by filtering out suspended impurities of air.

Cotton and wool are the commonest materials of which clothing is made. Linen is very similar to cotton, and silk to wool, in physical properties.

Cotton is much less absorbent of moisture, less permeable and a better conductor of heat than wool. Cotton consequently allows the perspiration of the skin to pass through it and conducts away the heat of the skin to cold air outside; it thus offers little obstacle to rapid cooling of the skin, and is not well suited to form the only clothing in changeable climates and when the skin is perspiring after exertion. It is, however, easily washed, cheap and durable, and well adapted for ordinary clothing in equable climates and for under-garments in all climates.

Wool, on the other hand, is very absorbent of moisture and a very bad conductor of heat, while at the same time it is very permeable to air. It is therefore an excellent material for clothing especially in cold and changeable climates and when the skin is perspiring after exertion. The chilling effect of too rapid evaporation from the skin is

* The amount of blood passing through the heart is greatly increased by abdominal compression. Hence abdominal belts may be useful in persons with weak circulation. *Vide* "The Physiological Bearing of Waistbelts and Stays," by C. S. Roy and J. G. Adami, British Association, 1888.

prevented by the absorption of perspiration by wool and the evolution of latent heat from the aqueous vapour so condensed.*

The warmth felt on investing the body with woollen clothing, especially when the skin is moist, is partly due to actual evolution of heat in this way and partly to the non-conduction of heat from the body to the outside air by the wool. The disadvantages of wool compared with cotton for under-clothing are its expensiveness and its not washing so well.

Impervious materials, such as greased leather and India-rubber, are useful for keeping out wet and retaining heat; but they retain the excretions of the skin and exclude purifying air, being therefore particularly objectionable in hot climates.

The color of clothing is of less consequence than the material; but black and dark colors are much more absorbent of heat than white and light colors. Poisonous coloring matters are sometimes employed for dyeing clothes; local irritation of the skin and even general ill-health may result.†

Exercise.

Disuse of muscles or other organs leads to more or less wasting of them: regular use of organs promotes their nutrition and growth. A moderate amount of exercise is therefore essential to the healthy development of the body in youth ‡ and to its healthy maintenance throughout life. Many ailments of persons who by occupation or choice lead sedentary lives are due to neglect of the physiological rule of exercise. Persons of inactive habits frequently eat a great deal more than they need for the work which they perform—this is one cause of disease—but no care in dieting

* See some discussion on this subject in *Nature*, 1881. The large evolution of heat in this way may be shown, as in the author's experiments, by wrapping the bulb of a thermometer in *dry* silk or wool and then exposing it to very damp air; a rapid rise of the thermometer to the extent of 10° F., or more, is the result.

† Arsenic is the most common injurious substance. It is an ingredient of several green pigments and may occur as an impurity in aniline dyes. The author lately found arsenic in some magenta-dyed socks which had caused an obstinate skin eruption in a patient at the Madras General Hospital

‡ Physical training in schools is now recognised as an educational requisite of prime importance.

can make up for deficient exercise. A certain amount of exercise is essential for good health.

The connection between food and work has already been considered in the Chapter on Food; it only remains now to examine the other physiological aspects of exercise.

During exertion the greatest strain falls upon the heart, blood-vessels, and lungs, the circulation and respiration being largely increased. All the functions of nutrition and elimination are secondarily stimulated.* The appetite is increased and the amount of food taken must of course be proportioned to the amount of exercise.

The best exercises for health are those which bring all the muscles of the body more or less into play, such as walking, riding, rowing. Exercise may sometimes be productive of evil effects. Thus violent or too long continued exertion, especially when there has been no gradual and regular training for it and when the food is insufficient, may be very injurious. Horses sometimes die from congestion of the lungs after violent exertion; and disease of the heart and blood-vessels is more common in men who occasionally make great efforts, such as artillerymen, oarsmen and athletes, than in those who practise less violent and more continuous exercises.

Training is necessary for any great or long continued exertion, in order to bring the various organs and tissues into a proper state of nutrition and accommodation. Without gradual training lassitude soon occurs.

If food be habitually deficient, wasting results from much exercise. Exertion leading to fatigue, when the usual food cannot be obtained, causes great exhaustion and may produce fainting or cholera-like collapse.

Drinking during exercise is necessary and beneficial; it is better to drink frequently than to take large draughts at long intervals. Drinking cold water and bathing in cold

---

* Dr. E. Smith found the quantity of air inspired by a man walking at the rate of three miles an hour to be more than three times as much as was inspired by the same man lying down, and when walking at the rate of four miles an hour it was five times as much. The same observer found that the amount of carbon dioxide in expired air was increased in proportion to the work done, for instance 5 grains per minute were evolved during sleep and no less than 18 grains per minute when walking at the rate of three miles an hour. Pettenkofer and Voit obtained similar experimental results with regard to oxygen absorbed and carbon dioxide evolved.

water when the circulation is excited by exercise can do no harm to healthy persons.

After exertion when the body has begun to cool and there is some sense of fatigue, woollen clothing should be put on. It is then that cold bathing and copious cold draughts are dangerous.

Exercise may be estimated and measured in *foot-tons*, that is, the number of tons which would be raised to a height of one foot by the energy expended. Conditions differ so much that an exact standard cannot be laid down for the minimum amount of exercise which is necessary for the preservation of good health. A very moderate amount of exercise is represented by half a foot-ton daily for every pound of body weight, and it is doubtful if an adult could enjoy vigorous health when taking less exercise than this. From two to three foot-tons per pound weight is a fair day's work for a laborer.*

The rapidity with which work is done is far more important than the actual amount of work with regard to its effect as exercise. A comparatively small amount of work done in a short space of time is far more exhausting and imposes a much greater strain on the heart, lungs, and muscles than a large amount of work done slowly. For this reason rapid exertion is best for those who work for health and pleasure and can only give a limited time to bodily exercise, while less speed is more suitable for those who have a large quantity of work to do.

TEMPERANCE

in all things is one of the highest sanitary virtues. Intemperance in food has been already alluded to. Occasional excess in this way is less injurious than habitual excess ; but the enormous eating, sometimes of unwholesome food, which

---

* The following data may be found useful. Professor Haughton has calculated that walking on level ground at 3·1 miles per hour is equivalent to raising $\frac{1}{20}$ of the weight of the body through the distance traversed. In ascending a height the whole weight is also raised through the vertical height ascended. The following formula may be employed to obtain foot-tons of work done in carrying a weight:— $\frac{(W + w) \times D}{20 \times 2240}$, W being the lbs. weight of the person, w the additional weight carried, D the distance traversed in feet (1 mile = 5,280 feet), 20 the co-efficient of traction, 2,240 number of lbs. in 1 ton.

takes place at wedding feasts and other entertainments, is often productive of acute illness, such as colic, diarrhœa, or dysentery, and sometimes death results.* Habitual intemperance in food causes dyspepsia, congestion of the liver, and other disorders which predispose to various diseases are productive of much discomfort and materially shorten life.

Intemperance in drink is generally confined to alcoholic liquors. Habitual drinking of raw spirit, a vice increasingly prevalent in some places, is the worst form of such intemperance. Diseases of the liver and blood vessels are common results of this form of intemperance. As has been already said in the Chapter on Food, the drinking of alcoholic liquors, even in small quantities, is a dangerous luxury; excess is not easily avoided, and, as a matter of fact, nearly all those who do take them at all do sometimes, if not frequently, take them in injurious quantity. It is in the experience of nearly every physician that "strictly temperate" persons, that is persons who are never even slightly intoxicated, do not rarely suffer from drinking too much alcohol. Statistics of friendly societies and of insurance offices distinctly prove that "total abstainers" from alcohol suffer much less from disease and live much longer than "moderate drinkers."†

The practices of smoking opium or ganjah and of eating them in sweetmeats or otherwise are very prevalent in some parts of the country and are hardly less noxious than drinking alcohol to excess. The action of these drugs is unfortunately too well-known to need description. The wretched condition, mentally and bodily, of persons who indulge in such practices, and the not uncommon commission of crimes during the delirium produced by ganjah, ought to deter others from indulgence in them.

---

* Some cases which reach the Chemical Examiner can hardly be attributed to any other cause.

† For instance in Manchester in 1886 the abstaining *Rechabites* had only 98 weeks of illness against 122 weeks among the non-abstaining Oddfellows and 126 among the non-abstaining Foresters. Again among the insured in the United Kingdom Temperance and General Provident Institution from 1866 to 1887 in the "general section" the expected deaths were 6,144 and the actual deaths 5,984, while in the "temperance section" the expected deaths were 3,937 and the actual deaths only 2,796—*vide* Report on Disease and Intemperance and other papers in the *British Medical Journal*, 1888.

Tobacco smoking is much less injurious, and in most cases it is practised with no very obvious injury to health.

Mental Hygiene.

Mental education and soundness have great influence upon development and health. There is much evidence that mental impressions of a pregnant woman may affect the development of the fœtus in her womb. The secretion and quality of milk is also affected by mental emotions. It is notorious that anxiety, care, disappointment, and all depressing emotions, have a very injurious effect upon health, while a contented and self-controlled mind is conducive to good health. It is therefore most important that healthy habits of mind should be cultivated. There is necessarily constant action and re-action between the brain and the rest of the body: ill-health has an injurious effect upon the brain as upon other organs, and unhealthy action or disease of the brain re-acts upon general health.

Healthy development and maintenance of the brain, as of other organs, are promoted by moderate, regular, intermittent exercise. Training increases its capacity for work within certain limits; but overwork is attended with temporary or permanent evil results.

The question of education on hygienic principles is too large a subject for us to enter upon; but it may be pointed out that hours of study are often too long, that when attention flags or the mind wanders from the subject, it is an indication of fatigue and it is time to desist or to change the subject, and that cultivation of the understanding is more advantageous and rational, though perhaps less attended to, than cultivation of the memory. Training is as necessary for great and prolonged efforts of mind as it is for great and prolonged efforts of muscle; sudden "cramming" for examinations and long hours of forced reading are apt to be attended with mental break down.

Marriage.

It is needless to describe the varieties of monogamy and female or male polygamy which exist among various races and in various religions. The sexes being nearly equal in numbers, monogamy is and must remain the custom of the great majority. Certain questions regarding marriage are however of great sanitary, social, and State importance;

those which more especially demand our attention are, so-called infant marriage, early marriage, intermarriage of blood relations, and marriage in connection with diseases transmissible by heredity or otherwise.

Infant betrothal is objectionable because the parties are disposed of irrespective of their consent and inclination and of disease or other occurrences in the long interval before consummation of the marriage can take place, because, by usage, a virgin widow is condemned to perpetual celibacy,* and because too early consummation of marriage is encouraged by it.

The question of early marriage, looked at from a purely physiological point of view, is easily disposed of. The effect of cohabitation at too early an age, before the physical development of the body is complete, is very injurious in both sexes. It prevents full and strong physical development of both, causes a lack of manliness and energy in the man, and exposes the immature woman to danger in child-bearing. The children of very youthful parents are probably less vigorous than those of matured parents: a mother who has to provide for the growth of her own body as well as for that of the child she is bearing is likely to starve both. It has been urged in favor of early marriage that the suppression of an important physiological function must be prejudicial to health, and, on this ground, marriage should take place in both sexes at puberty; but it is a matter of common experience to many besides physicians that sexual indulgence before bodily growth is complete is disastrous to health.

The mortality of the married under 20 years of age has also been shown by statistics † to be excessively high in both sexes. It must therefore be concluded that early marriage, that is, marriage before growth and bodily development are complete, is decidedly injurious to health.‡

---

* Professor Max Müller in his *Hibbert Lectures*, 1878, pp. 352-3, showed that infant marriage is really opposed to Hindu religion, and that the religious argument in its favor cannot hold ground.

† French vital statistics quoted by Farr.

‡ "Manu wishes a young man to marry when he may become a Grihastha, *i.e.*, when he is about 24 years of age. As to the girl she is to marry when she is fit for it." *Max Müller* (letter to Mr. B. M. Malabari). As we have pointed out a girl cannot be considered really fit for marriage and the exhausting duties of maternity until her growth is complete.

The question of early, in the sense of *improvident*, marriage has important bearings for the philanthropist, the political economist and the sanitarian, which can be only briefly alluded to here. In countries where early marriage is a prevalent custom, not only are marriages more numerous, but the number of children born to each marriage is much larger than in countries where marriages are usually contracted later in life, with a more prudent regard for the means of rearing progeny.* One result is that in populous countries where improvident marriages are the rule, the population tends to increase in a more rapid ratio than the means of subsistence and it is naturally reduced by the "misery check" † of famine and disease. In those countries, on the other hand, where later marriages regulated by prudential considerations regarding the support of children are the rule, the population increases more in proportion to the means of subsistence and is less liable to be thinned out by famine and disease. The voluntary "prudential check" to population, in the shape of provident marriage, is therefore often a wise and efficient provision against misery and disease. It has been argued that an early marrying race or class must "breed down" and supplant a later marrying race or class.‡ But there is a great fallacy in such an argument; the conditions are dissimilar. The more prolific early marrying race may, and is likely to be, less provident, less vigorous, less wealthy, and consequently much more affected by the "misery check" than the later marrying race who adopt the voluntary "prudential check." The same rule applies to individual families; the offspring of the more prudent and well-to-do is less subject to the "misery check" than that of the less prudent and the very poor.

It has also been advanced that in a rapidly breeding race improvement takes place by "survival of the fittest." The fittest under such circumstances, however, would be the

---

* Dr. Mathews Duncan gives the following returns from the Lying-in Hospital of St. George's in the East—

Age of mother at marriage ...	15–19	20–24	25–29	30–34
Average fecundity	9·12	7·92	6·30	4·60

India may be taken as an example of a country where improvident marriages are the rule; in England, on the other hand, statistics show that the marriage rate is influenced by prosperity and means of subsistence.

† Malthus.

‡ See *Inquiries into Human Faculty*, by F. Galton, 1883.

fittest to exist under depraved conditions; and it can hardly be doubted therefore that early and improvident marriage and too rapid breeding are to be condemned on evolutionary principles as tending to degrade the race.

All these considerations indicate unmistakably that not only infantile marriages but all improvident marriages are fraught with evil to the family and to the race. No sudden change of social habits is possible, but it is a question of deep concern for all thoughtful and influential persons to gradually educate the masses to truer conceptions of the responsibilities and consequences of marriage.* Unfortunately the very poorest classes are the greatest offenders, as they are also the greatest slaves of custom, in this respect.

In comparing the circumstances of this country with those of other countries where more provident habits prevail, the effect of early marriage on population and mortality should not be lost sight of by sanitarians and administrators.

The inter-marriage of blood relations is often objectionable because their progeny has a double chance of inheriting any weaknesses or tendencies to disease which are common to their ancestors. Nervous temperament or disease (including mental disease) is likely to be thus transmitted or increased.† On the other hand if the stock be a vigorous and healthy one, the inter-marriage of relations may increase some desirable family qualities.‡

Several diseases and tendencies to disease are hereditary. The marriage of persons actually affected with hereditary disease, such as syphilis and probably leprosy, should be discouraged as an immoral act fraught with evil to their offspring and tending to disseminate disease. The inter-marriage of persons affected with or who have a family tendency to certain diseases, such as scrofula (including consumption), rheumatism, gout, insanity, is also to be discountenanced, because the children of such inter-marriage would have a double chance of inheriting the diseased tendency.

This subject cannot fitly be concluded without saying a few words upon the evil consequences of sexual abuses.

---

* "Little advance can be expected in morality until the producing of a large family is regarded in the same light as drunkenness or any other physical excess."—*J. S. Mill.*

† *Cretinism* has been attributed to breeding in-and-in in small isolated communities.

‡ This fact is well-known to breeders of horses, farm-stock, and dogs.

The effects of venery in the young have been alluded to under the head of early marriage. Excessive sexual indulgence is very injurious in adult life, but doubly so in youth; it produces general nervous depression with mental and muscular weakness, and results in premature loss of sexual power, early aging, and sometimes in actual disease of some part of the nervous system. Over indulgence in married persons is often the result of ignorance, and in the unmarried it is encouraged by the stimulation of lewd companionship, obscene literature, and the lures of prostitution. Notwithstanding the custom of early marriage, various forms of sexual depravity occur amoung youths in this country, and it is a manifest duty of parents or guardians of children to explain to them, as soon as they reach the age of puberty, the nature of and the dangers to health and loathsomeness attending such practices. They cannot be brought up in ignorance of sexual passion, and the sooner they are instructed in the mysteries of sexual physiology and have explained to them the necessity of controlling this passion and the danger of its abuse, the easier will it be for them to avoid the rocks which beset the path of ignorance. Healthy exercise of body and mind, unstimulating diet and chastity of thought render continence easy. There is no danger in continence but great danger in excess, and everything which stimulates the sexual passion may be a source of danger to health.

Maternity.

The health of pregnant women needs special attention not only for themselves but for the sake of their offspring. Unwholesome or insufficient food, excessive work, and depressing mental emotions or violent excitement are often more injurious to the offspring than to the mother. During the great famine, mothers who did not themselves exhibit any great bodily wasting often gave birth to extremely emaciated and evidently starved infants; a generous diet is therefore necessary for pregnant women.

During and after child-birth cleanliness of person, free ventilation of the lying-in room and a sufficiency of wholesome food for the mother must be provided.*

* The native mode of treatment of women in accouchement is one of peculiar hardship and torture to the patient. Kanny Lall Dey: *Hindu Social Laws and Habits.*

The prevalent custom of suckling children until they are three years old is injurious to the mother as well as to the child. The effect of prolonged lactation is very exhausting, and if a woman become pregnant during lactation, the nutrition of the fœtus in the womb is interfered with. A child ought as a rule to be weaned when its first teeth appear. A nursing mother requires almost as much care and nourishment as a pregnant woman: bad food, excessive work, or mental emotion may interfere with lactation or cause the milk secreted to be of injurious nature.

The Four Ages of Man.

The lifetime of man may be divided into the four periods of infancy, youth, maturity, and old age.

The well-being of an infant depends almost entirely upon its mother. Infants should as a rule be suckled by their mothers; a foster-mother is, however, desirable when the mother is very feeble or is affected with some disease, such as scrofula, which may possibly be communicated to the infant. If fed on cow's milk the addition of a little sugar is useful, and care should be taken to obtain the milk of a healthy cow. If there be any doubt the milk ought to be boiled. It is a common fault to feed infants too frequently; over-fed infants often cry because they suffer from indigestion and not because they want food. They should not as a rule be fed more frequently than at intervals of three hours, so that the digestive organs may have some periods of rest. Weaning should gradually take place when the teeth appear, or the infant is about eight months old. Small quantities of gruel may be given at first, and by degrees this may be supplemented by some easily digested solid food. The practice of distending the stomachs of infants and young children with large quantities of food such as is taken by adults is strongly to be reprobated. Large quantities of sweetmeats are objectionable, and highly-spiced articles of diet should also be avoided. Young children require to be fed more frequently than adults and (as explained in the Chapter on Food) need a larger relative quantity of food. The giving of opiates or stimulants to children need only be mentioned to be condemned.

The cleanliness of infants and children is too often neglected. When they are washed it is frequently by pouring cold water over them in a current of air, a likely

method of inducing internal congestions. Immersion in water, or at all events protection from wind during ablution, and rapid drying by friction with a cloth is the proper practice.

No clothing is commonly worn by infants and young children in Southern India and they not rarely suffer from exposure to vicissitudes of temperature. It should be borne in mind that children are more sensitive to changes of temperature and possess less vital resistance than adults, consequently they need more rather than less protection.

The care of young persons during youth, the period of active development and growth, and the due inculcation at this time of habits of self-control and cleanliness, are matters of the highest possible importance which have been previously alluded to and need scarcely be further insisted upon here. The attention which is now being paid to *physical* culture in our schools is a step in the right direction and one which deserves further extension.

The period of adult life may be regarded as extending from the time when growth is complete, that is, between the ages of 20 and 26 years, and the time when decay begins, that is, in healthy persons, between the ages of 40 and 60 years. This is the period during which the bodily powers are in the highest state of development and activity, but the mental powers do not generally attain their full ripeness till towards its close.

In old age the hair becomes grey or white, the sight and hearing become less acute, muscular and digestive power diminish, sexual power declines, fat under the skin becomes absorbed, the skin becoming less elastic and more dry and wrinkled, the bones become hard and brittle, and the tissues of the body tend to degenerate. Old persons require more digestible food, warmer clothing and less work than adults.

Vitality and Longevity.

It is notorious that some individuals are much more apt than others to contract disease, and they succumb more easily to it or recover more slowly and less perfectly. The vitality of such persons is low and they are as a rule short-lived. Others, on the contrary, do not readily contract disease and they recover from it more rapidly and perfectly. Such persons possess a high degree of vitality.

Vitality may be partly inherited and partly acquired. Healthy, vigorous, and long-lived ancestors tend to produce healthy, vigorous, and long-lived descendants. Healthy rearing and physical education of children has much influence in increasing or preserving their natural vitality; and, throughout life, hygienic surroundings and habits affect the vitality of individuals in a favorable manner. On the other hand, all unhealthy surroundings and habits affect vitality unfavorably. Excesses of all kinds, such as in eating, in alcoholic drinks, and in venery, exert a powerful depressing influence. Most long-lived persons are of moderate habits, a little above average height, and of rather spare condition.* From all the evidence we possess, it must be inferred that, although vitality is in part an inherited quality, yet it is to a large extent within the power of individuals themselves to increase or reduce their own vitality.

Long life and good health are as much due to good vital resistance, whether hereditary or promoted by hygienic personal habits, as they are due to protection from exposure to disease. If the tissues of the body possess a vigorous life of their own, disease-microbes cannot readily destroy or grow upon them and they will recover rapidly from various causes of depression or irritation, which would impair or destroy tissues of lower vitality. To afford protection from exposure to disease is the main function of Public Hygiene; to increase vital resistance to it is mainly one of Personal Hygiene.

---

* See *Report on Aged Persons* (Collective Investigation Committee of B.M.A.), by Professor Humphrey, F.R.S., *British Medical Journal*, March 10, 1888.

CHAPTER IX.

PREVENTION OF DISEASE—PHYSIOLOGICAL DISEASES. PARASITIC DISEASES.

Classification of Diseases.

For the prevention of disease in a scientific, that is in the most rational and effective manner, the causes of disease must be known with accuracy. But knowledge of these causes is still very imperfect, the causes of some diseases have been ascertained with more or less exactitude; some other diseases, though not yet traced to their sources, are, by analogy, believed to be of nature similar to better known diseases; yet other diseases exist whose causes are still obscure. The classification of diseases according to their nature must therefore be imperfect; still this appears to be the most correct method to adopt.*

The simple divisions which were defined in the introductory chapter may be accepted as, at all events, provisionally suitable to the state of knowledge. Diseases of which the causes are known can readily be referred to the class of physiological or that of microbic or that of parasitic diseases. Diseases of which the causes are not yet known with certainty, but which present characters closely analogous to those of certain known diseases, should be classed with the diseases which they most resemble. Diseases whose origin and nature are obscure, but which may *possibly* be microbic or parasitic and communicable, it is safest to regard as though they were certainly microbic or parasitic and communicable. No harm can be done by treating a non-communicable disease in this way, while, if it prove to be communicable, measures will have been adopted to prevent its spread. Although diseases may be broadly divided into those three classes, yet diseases which are classed together may differ remarkably from one another.

* Some of the difficulties of disease classification have been lately discussed by Dr. T. Clifford Allbutt in his *Address in Medicine, British Medical Association*, 1888, and by Dr. W. S. Gouley of New York, *Diseases of Man*, 1888.

It often occurs, however, that some diseases in each class, though differing specifically from each other, possess certain common secondary characters and resemblances by which they may be naturally grouped together: groups or *natural orders* may thus be distinguished.

The division of diseases into classes and groups is of great assistance in discussing measures for their prevention; but even closely allied diseases present so many differences among themselves that the necessity of studying each disease separately must not be overlooked. This study, however, must remain the special province of medical experts; we shall here consider only the more general principles of prevention with particular allusion to but a few of the most important diseases.

PHYSIOLOGICAL DISEASES

are due to some local or general impairment or alteration of function, with or without sensible alteration of structure, and not caused by microbes or parasites.

The principal causes of these diseases are, heredity (individual or racial); deficient, excessive or improper food or exercise; climatic influences.

Some physiological diseases are believed to bear a close analogy to many microbic diseases, inasmuch as the decompositions or fermentations produced by the living cells, of which the organs and tissues of the body are composed, are comparable with decompositions or fermentations set up by growing microbes. The organs and tissues of the body, even in health, produce, as results of their own disintegration and wear and tear, or by certain decompositions or fermentations of blood or other fluids, various materials, some of which are actively poisonous.*

During health such effete materials are excreted by the kidneys, skin, bowels, or lungs, some being oxidised in the blood, and they are thus removed almost as fast as they are

* Especially those resulting from decompositions of albumenoids, as *leucomaïnes* (Gautier) and *extractives*. The former resemble alkaloids and similar substances (*ptomaïnes* of Selmi) which are formed, under the influence of growing microbes, in decomposing albuminous materials. Extractives are of undetermined chemical nature, but some of them are intensely poisonous.

Dr. A. L. Brown (*Animal Alkaloids*) states that poisoning by extractives is attended by lowering of bodily temperature and poisoning by animal alkaloids causes rise of temperature.

produced. Disease may result from their retention in the body owing to excessive production or defective excretion.*

Poisonous products of this kind act with intensity in proportion to their quantity; their effects are rapidly manifested, there being no incubation; they are not capable of self-multiplication; they are not communicable by infection, contact, or inoculation. In these respects physiological differ markedly from microbic diseases. The following important groups are contained in this class: —

Malformations and weaknesses, hereditary or acquired.
Constitutional diseases, rheumatism, gout, diabetes, &c.
Dietic diseases, dyspepsia, some forms of diarrhœa, scurvy, starvation, obesity, rickets.
Chemical poisons, alcoholism, lead poisoning.
Morbid growths of tissue elements, tumors.
Degenerations, fatty, caseous, calcareous.
Local inflammations or functional derangements due to heat, cold, or mechanical or chemical irritants, surgical injuries.

Prevention of Physiological Diseases.

The prevention of these diseases, in so far as they are preventable, is mainly a question of personal hygiene. Many points connected with their prevention have already been noticed in the Chapters on Food and Personal Hygiene, and need not be repeated further than to observe that the measures which conduce to prevent these diseases by preserving the healthy physiological action of all the organs of the body—in other words, a healthy habit of body—serve to increase vital resistance and strengthen the tissues against the invasion of microbic diseases also. Morbid hereditary tendencies should be particularly combated.

PARASITIC DISEASES.

All animals, except those of minutest size and simplest structure, and many vegetables, are liable to the attacks of animal parasites. Everywhere we find that "big fleas have little fleas to bite 'em." Many parasites confine their attacks to particular species of animals and cannot live upon other species; others are more indiscriminate, being capable of living upon even widely different species; while yet others

* Vide *Harveian Oration*, October 1888, by Dr. Latham of Cambridge.

Plate IV.

Parasites.

1. EGGS of *a. Ascaris lumbricoides*, *b. Dochmius duodenalis*, *c. Distomum lanceolatum*, *d. Tænia solium* × 400 (after Leuckart).

2. CYSTICERCUS (*Tænia saginata*); *a.* in flesh natural size, *b.* head protruded × 3 (after Leuckart).

3. FILARIA MEDINENSIS (embryo) × 200 (after Cobbold *reduced*).

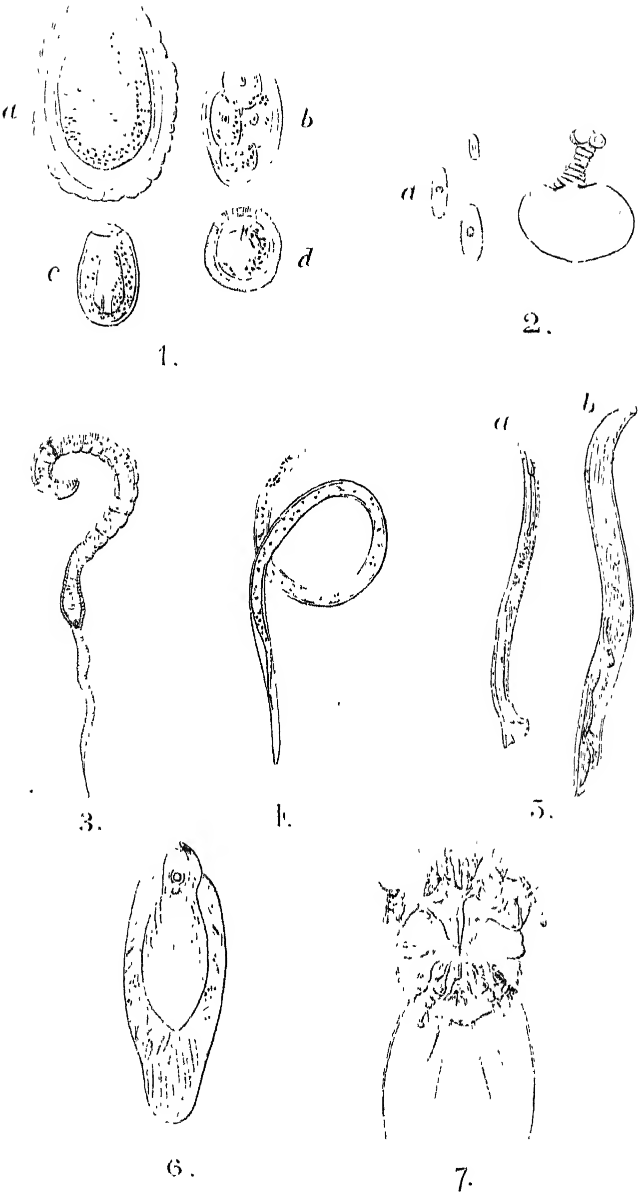
4. FILARIA SANGUINIS (embryo) × 300 (after Lewis).

5. DOCHMIUS DUODENALIS, male and female × 5 (after Cobbold).

6. DISTOMUM HEPATICUM, natural size (after Leuckart).

7. ACARUS SCABIEI, male, ventral surface × 400.

Plate IV



require two species of animals for their complete development, passing the first or larval stage of their existence in one animal, and the second or mature stage in another animal. Some parasites also pass a portion of their lives in a free non-parasitic state.

Animal parasites (like microbic and larger vegetable parasites) are most likely to attack individuals of low vitality, the diseased, underfed, very young and very old; but perfect health is no guarantee against the attacks of many of them.

Some human parasites, such as hydatids, blood filariæ, and trichinæ, occasion serious disease and frequently death; others, such as tape-worms, round-worms, flukes, and guinea-worm, less frequently cause dangerous disease and rarely death; others, such as thread-worms, itch acari, and lice, are not apt to affect health except by the local discomfort or injury to which they give rise; while others, such as some protozoa found in the intestinal canal and some mucous tracts, appear to be harmless to their hosts.

Some parasites are permanently parasitic, that is, they cannot exist apart from their hosts; others, such as fleas, bugs, ticks, mosquitoes, leeches, flies, and the larvæ of flies are only occasionally parasitic.

Parasites, except those which attack the skin, gain entrance to the body with food or drink; sometimes from eating with soiled fingers; the eggs or larvæ being thus swallowed.

Those which attack the skin are communicated by contact, or dirty clothes, or even carried through the air, and they are encouraged by dirty habits. Debility predisposes to the attacks of parasites of all kinds.

The prevalence of parasitic disease is therefore certain evidence of bad sanitation. If water and food be uncontaminated and healthy, and if person, clothes and surroundings be kept clean, parasitic diseases cannot occur.

Parasites have been divided into *ectozoa*, or those which affect the exterior of the body, and *entozoa*, or those which affect its interior.

Besides the occasional parasites already mentioned, *ectozoa* comprise lice, itch acari, and minute acari (*demodex*) which inhabit sebaceous follicles in the skin.

The following is a list of the most important *entozoa* which affect man in India and the means by which they enter the body * :—

1. *Trematoda* (*Flukes*).

   Fasciola hepatica and various species of *Distoma*. These are rare in man, but common in fish, sheep, and cattle; fish are believed to be their natural habitat. Source: undercooked flesh and contaminated water.

2. *Cestoda* (*Tape-worms*).

   Tænia medio-canellata, from insufficiently cooked "measly" beef, which contains its larvæ (cysticerci).

   Tæniæ and *Bothriocephali* of various species, from flesh of other animals.

   Echinococcus hominis (*hydatid* or *bladder-worm*), from the excrement of dogs affected with *tænia echinococcus* or from water to which such dogs have access, probably also from jackals.

3. *Nematoda* (*Round-worms*).

   Trichina spiralis, from insufficiently cooked flesh of pigs affected with it. It has not been recorded in Indian pigs.

   Trichocephalus dispar, from contaminated water containing its eggs.

   Filaria sanguinis (*Blood-worm*), from impure water containing its larvæ, which are sucked from the blood of affected men by mosquitoes and by them carried to water.

   Dochmius duodenalis (*anchylostomum duodenale*), from contaminated water containing its eggs. This worm appears to be common in India, but it has until recently been overlooked.

   Filaria medinensis (*Guinea-worm*), from infected water. It is still a debated question whether it enters through the skin while bathing or in drinking-water.

   Oxyuris vermicularis (*Thread-worm*), from eggs swallowed in contaminated water or food. It is also contagious from person to person.

   Ascaris lumbricoides (*Round-worm*), same as *Ascaris suilla* of pig. Acquired from contaminated water or soiled vegetables which contain its eggs.

Prevention of Parasitic Diseases.

The methods to be adopted for the prevention of these diseases are simple and obvious.

* This list is taken, with some alteration and addition, from Cobbold.

The lodgment of *ectozoa,* such as itch-acari and lice, may be prevented by cleanliness of person and clothing and avoidance of contact with affected individuals. Clean dwellings ought to be free from fleas, bugs, and ticks; but it should be noted that fleas and ticks are apt to be introduced by domestic animals.

Entozoa are most commonly acquired by drinking polluted water containing their eggs or larval forms. Their eggs may also be conveyed on vegetables or fingers soiled with excrement containing them. Tape-worms are acquired by eating the under-cooked flesh of animals containing their larval forms; thorough cooking kills these. Trichina is acquired in the same way. An uncontaminable water-supply is the first essential for the prevention of all these parasites. All water which is not above suspicion should be well boiled to kill their ova or larvæ. Doubtful vegetables should be cooked, and suspected meat also, if eaten, should be well cooked.

The evacuations of persons affected with intestinal parasites should be burnt or buried deeply. Water polluted with such evacuations containing ova is the most fertile means of propagation of these parasites. Animals may also be infected by eating the excrement or grass which is soiled by it, and man by eating vegetables manured with it. It may be useful here to give a little further information concerning some of the most common parasites with a view to measures for their prevention.

Lice in clothes may be destroyed by boiling. On the body it must be remembered that they leave their eggs attached to hairs; and, though the lice may be destroyed by mercurial ointment or otherwise, the eggs are hatched and give rise to a new brood at the end of 5 or 6 days.* Any vermicide used must therefore be applied continuously for a week.

Itch is caused by the burrowing of a minute *acarus* in the skin. It may be seen with the aid of a lens, and is not uncommonly found in clothes or even floating about in the air in places where there are persons affected with the disease. To prevent its recurrence the application of sulphur, or whatever other remedy is used, must be continued

* Lice are hatched at the end of 5 or 6 days and reproduce at the end of 18.—*Van Beneden.*

for a considerable length of time in order to destroy the young acari as they are hatched from the eggs which are left in the skin.

Tape-worm is common in parts of Northern India, but rare in Madras. The beef tape-worm can obviously affect only Mahomedans, Christians, and other beef-eaters. Its life history is as follows: Water is polluted with the excrement of men affected with the tape-worm, and its eggs thus pass into the water (one worm produces some 50,000 eggs). Cattle drink this water, the eggs are hatched in their bodies, and the larval or immature worms burrow into their flesh where they are known as *cysticerci* or bladder-worms.* These may be destroyed by very thorough cooking; but, if not so destroyed in flesh which is eaten by men, they become developed in the intestines into complete tape-worms.

An immense number of other species of tape-worm is found in various animals, but few of them are communicable to man.

Hydatids or cystic disease, caused by the larvæ of a tape-worm (tænia echinococcus) which affects the dog and jackal, are occasionally found in men, but are more common in cattle, all over India.† Access of dogs to drinking water intended for man should therefore be prevented.‡

Filaria sanguinis or blood-worm.§ Embryos of this worm are found in the blood of persons affected with elephantiasis, lymph scrotum, and chyluria. The adult worms live in the lymphatic vessels. The female, a hair-like worm 3 inches long, is viviparous and may live for

---

* "Sometimes as much as 14 per cent. of horned cattle slaughtered at Rawal Pindi are affected with cystic disease."—*Report of Indian Cattle Plague Commission*, 1871.

† A case of hydatid of the brain has lately been recorded by Surgeon Armstrong in the Madras Lunatic Asylum.

‡ In connection with this point it may be of interest to note that dog's excrement is not uncommonly employed by native quacks as a medicine!

§ The embryonic filaria was discovered by Lewis in Calcutta in 1870. Its history has been elucidated by him, Dr. Manson, and Dr. Bancroft. The embryos found in the blood are microscopic; the adult worm, discovered by Bancroft, has been found in the lymphatic vessels, and is a hair-like worm half an inch long. A female and the second male specimen recorded were lately found by Brigade-Surgeon C. Sibthorpe in Madras and described by Dr. A. G. Bourne. *Transect, S. I. Branch B. M. A.*, April 1888. Before the discovery of the filaria, Sir Joseph Fayrer had surmised that chyluria and elephantiasis might be due to a parasite.

years in a man without causing inconvenience to her host so long as she discharges only developed embryo-worms which pass through the lymph-glands into his blood. But she occasionally aborts; and the ova, being too large to pass the lymph-glands, cause obstruction and disease. The embryo-worms appear to be sucked from the blood of affected persons by mosquitoes. These mosquitoes go to lay their èggs in water and there die, the filariæ escaping from their bodies into the water. It is believed that they thence find their way into their human hosts.*

Dochmius duodenalis (*Anchylostomum*). This small worm inhabits the upper part of the intestine and is often overlooked by pathologists owing to its small size and its being of the same color as the lining membrane of the intestine to which it clings. It had been previously known in Egypt and was first found in India by Dr. McConnell of Calcutta. It was noticed in Madras in 1883 in a case sent to the Chemical Examiner from South Arcot. Many cases have since been recorded at the General Hospital, Madras. It appears to be transmitted usually by eggs in polluted water, in the same way as the common round-worm. It causes anæmia which may end fatally.

Round-worm (*Ascaris lumbricoides*). This is the commonest of all intestinal parasites in India, and it is found in every part of the world. Its local prevalence has been investigated in England,† and it was found to be most common in places where the water was polluted. Its extraordinary prevalence all over India is no doubt connected with the widespread fœcal pollution of drinking-water which prevails everywhere. In India it is exceptional to find an individual who does not harbour some of these parasites!

Guinea-worm is endemic in many places. It takes about a year to mature after its entrance into the body. The point is not yet settled as to whether it enters in

* Manson relates the importation of elephantiasis into Barbadoes by a single individual. "The mosquitoes sucked his blood, and with it embryo filariæ; they were thus disseminated, and the disease has ever since been endemic in the island, where it was before unknown." Sir Joseph Fayrer: *Tropical Diseases*. Elephantiasis is a common disease in various tropical countries. In Southern India it is particularly prevalent at Cochin and Sriharikota on the Pulicat Lake. The author found about 10 per cent. of the population affected at the latter place.

† By Dr. G. Wilson.

drinking-water or through the skin in bathing. H. V. Carter supports the latter view, and the author's limited experience is also in favor of it.* The milky juice which exudes from the mature worm contains myriads of embryonic worms.

---

* In 1873-74 when he was in charge of the 3rd Madras Light Infantry at Secunderabad, guinea-worm became very prevalent in the regiment. He noticed that it occurred mostly, if not exclusively, among men who bathed in a certain tank. On the use of this tank being prohibited, the disease disappeared. On one occasion he removed from under the skin of a patient a *half-grown* pink colored guinea-worm. Vide *Indian Annals, Med. Sci.*, 1874.

CHAPTER X.

MICROBIC DISEASES.

Microbic diseases are caused by the growth of microphytes, which may enter in various ways, according to their kind, by the mouth, lungs, skin, or through a wound, and multiply in the body, often showing an "elective affinity" for growing in certain tissues. They may act by causing local irritation or destruction of tissues, or blocking of vessels, or by producing (as alcohol is produced by the growth of certain organisms in fermenting toddy) a substance which acts as a chemical poison.*

It is possible that, in some cases, poisons produced outside of the body by the growth of certain microbes may enter the body and cause disease without the entrance of the microbes themselves.†

---

* This class comprises the diseases termed by Farr "zymotic" or ferment-diseases. Two kinds of ferments are known: (1) *organised or living*, and (2) *soluble or chemical* ferments. Chemical ferments are needed in definite proportion to cause fermentation of a certain quantity of material, because *they do not reproduce themselves;* but the minutest quantity of an organised ferment is capable of setting up fermentation in an indefinitely large quantity of material, because organized ferments *reproduce themselves* during their period of activity. "As a general rule all purely *physiological* fermentations are brought about by soluble ferments and *pathological* fermentations by organised," (Charles, *Physiological and Pathological Chemistry*, 1884). *Torula* cells of yeast and small-pox *cocci* may be instanced as examples of living ferments; *diastase* and *peptone* as examples of chemical ferments. Even before certain special disease-microbes had been recognised by the microscope, the virus of inoculable diseases was shown to consist of solid particles by Chauveau (1868), who found that it sank to the bottom of a fluid; and Burdon Sanderson and Pasteur separated it from liquids by using porous porcelain filters.

† Some, if not most, microbes appear to act pathologically by producing chemical ferments which set up secondary changes in the media in which they exist resulting in the production of more or less poisonous *leucomaïnes* and *extractives.* Panum found that putrefying material in which the microbes had been destroyed by long boiling retained its poisonous properties, thus proving the actual poison to be of chemical nature. Koch suggested that Dr. Vincent Richards' experiments in which cholera appeared to be communicated to pigs by feeding them on large quantities of cholera dejecta really showed poisoning of this kind, for the disease was not further transmissible to other pigs, and cholera *bacilli* are, under ordinary circumstances, destroyed in the stomach.

Several of these diseases, such as tubercle, anthrax, rabies, are common to man and lower animals and may be transmitted from one to the other.*

The most important common characters of microbic diseases are the following: each of these diseases is due to a specific micro-organism, and therefore each case of such disease can only be originated, directly or mediately, from a previous case of the same disease †; the organisms which cause these diseases are capable of indefinite multiplication under favorable circumstances, within the body or external to it, and often are multiplied to an enormous extent in the bodies of affected individuals; many microbes show a preference for particular organs or tissues and for particular individuals or races (in the same way that larger plants show preferences for particular soils); there is a period of latency or *incubation* between the time of reception of disease-producing microbes in the body and the first symptoms of disease, (being the period required for germination and multiplication of the organisms); many microbic diseases run a definite and limited course ‡ and, in such cases, one attack usually protects against further attacks of the same disease.

Microbic diseases are capable of communication by aërial infection (germs being conveyed by air), by swallowing, by contact directly or by means of infected articles, or by inoculation; but each disease is ordinarily communicated in only one of these ways.

---

* It may be that some microbic diseases of vegetables are also transmissible to man. Malaria has been recently attributed to organisms which resemble certain epiphytes and may perhaps belong to the animal rather than to the vegetable kingdom. If they were proved to be protozoic forms, our definition of microbic diseases would require extension to include microzootic as well as microphytic origin. Amœboid monads have been found by Lewis, and later by Koch, in the blood of rats.

† This is the commonly accepted doctrine, but it cannot be considered logically proved until it is shown that innocent microbes may not, under certain conditions, become disease-producing, and there is some support for the opinion that they may.

‡ Especially the acute contagious fevers—the organisms behaving like a crop of large plants or of fermentation-organisms—indeed it is certain that disease-microbes do cause specific fermentations. By cultivation of microbes in the laboratory, it has been found that, circumstances being similar, each microbe always produces the same decompositions in the material in which it grows. Nicati and Rietsch found that the cholera bacillus produced a ptomaïne which they assert caused symptoms of cholera; Gautier found a somewhat similar alkaloid in cultures of the enteric bacillus; and Brieger obtained a tetanus-producing ptomaïne from cultures of the tetanus bacillus.

Plate V.

Microbes.

1. Anthrax (*Bacillus anthracis*) : *a* fresh, *b.* stained specimen, × 700 (Klein).

2. Tubercle (*Bacillus tuberculosis*) : *a.* (Koch), *b.* (Klein), × 700.

3. Leprosy (*Bacillus lepræ*): *a.* × 600 (Cornil et Suchard), *b.* × 1000 (Klein).

4. Small-pox (*Streptococcus variolæ*): × 700 (Klein).

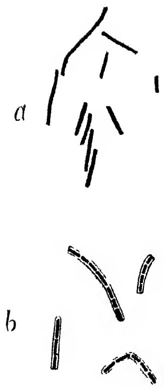
5. Pneumonia (*Diplococcus pneumoniæ*): *a.* × 700, *b.* enlarged and highly magnified, showing *encapsuled* cocci (after microphotograph by Koch).

6. Cholera (*Spirillum choleræ?*): × 600 (after Koch).

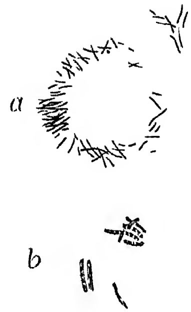
7. Relapsing Fever (*Spirillum obermeieri*): × 750 (Carter).

8. Malaria (*Plasmodium malariæ*): *a.* and *b.* × 900, others × 1800 (after Marchiafava and Celli). *a.* free pigmented body in blood in process of scission, *b.* free pigmented body furnished with filaments like flagella, *c.* amæboid *plasmodium* within a red blood corpuscle, *d.* two plasmodia, one pigmented, in one corpuscle, *e.* pigmented plasmodium in a corpuscle, motionless plasmodium passing out of a blood corpuscle.

9. Actinomyces: *a.* × 700 (Klein), *b.* more highly magnified (after Israel).



1.



2.

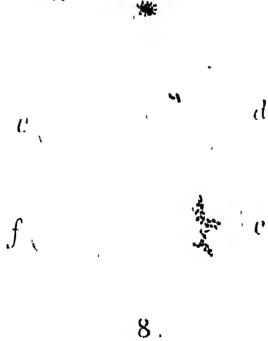
3.

4.

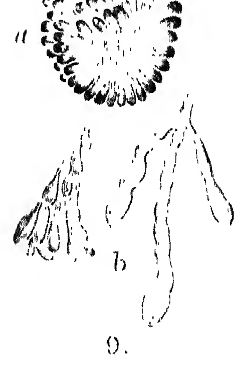
5.

6.

7



8.



9.

The analogy of microbes with larger plants is obvious.* Seeds sown in fertile soil remain latent for a definite period, but eventually give birth to a crop of plants which run a certain course of life and multiply the original seed many fold. Each plant can only be propagated from the specific seed of a similar plant: rice seeds will only produce rice-plants, and small-pox seeds will only produce small-pox.

Plants of the same specific nature may, however, exhibit differences of vigor and variations, depending upon differences of soil, season, or other conditions. Differences of activity, and character in the same disease in different climates or among different races, or in different epidemics, may be similarly explained—indeed by artificial cultivation under certain conditions, or by growth in certain species of animals, some known disease-germs may be modified so as to have their virulence increased or diminished.†

Modifications of breed occur very much more rapidly in microbes than in large plants, because the former go through very many generations in the time occupied by one of the latter.

Forms and Characters of Microbes.‡

The study of microbes has been followed (1) by observing their microscopic appearances, including their mode of propagation and development and the changes which they undergo in varying conditions of natural growth or artificial cultivation, and the peculiarities they exhibit in staining with certain dyes §; (2) by observation of the physical characters (such as color and shape of mass) of their growth in masses or crops when cultivated artificially; (3) by exami-

---

* This analogy may be so unmistakably traced in the clinical course and general history of many diseases in which specific microbes have not been fully demonstrated that such diseases are now generally regarded as microbic. On sanitary grounds, as already explained, it is most desirable that they should be so regarded.

† Notably the *anthrax bacillus* and the microbes of several other diseases of animals—most recently *rabies*—as cultivated by Pasteur. Cow-pox is by some pathologists believed to be small-pox modified by transmission through the cow.

‡ This is a matter which can be only very superficially touched upon here. For fuller information the scientific reader may refer to Klein's *Micro-organisms and Disease*, Crookshank's *Manual of Bacteriology*, Translations of papers by Koch, Pasteur and other foreign workers, edited by Watson Cheyne for the *New Sydenham Society*, Watson Cheyne's Lectures, and various recent works on Pathology.

§ It is often difficult or impossible to see some microbes without such staining.

nation of the chemical changes which they produce in the material in which they grow; and (4) by observation of the diseases which are produced by some of them.

Bacteria.—The vast majority of disease-microbes hitherto discovered belong to an order of extremely minute organisms of apparently very simple structure termed *Bacteria* or *Schizomycetes* (fission-fungi), the latter name indicating that they multiply by division, each half becoming a separate organism. Some species may multiply in this way with extraordinary rapidity. Bacteria have been classed, according to shape,* into (1) spherical or ovoid bacteria (*micrococci*); (2) short rods (*microbacteria*); (3) long rods (*bacilli*); and (4) spiral rods (*spirilla*)†. Many bacteria are motionless, but some are *motile* and exhibit very lively movements caused by rapid lashing of one or more extremely fine whip-like processes (*flagella*). Bacteria comprise a large variety of species and are widely diffused in nature, being found almost everywhere in more or less abundance. Some species resemble each other so closely in appearance and size that it is scarcely possible by microscopic examination alone to distinguish them from one another. If we can imagine large plants to be reduced to the minute size of bacteria, it would be equally difficult to distinguish many which we know are specifically distinct.

The conditions necessary for the growth of bacteria are (1) nitrogenous material suitable for their nourishment, (2) moisture, and (3) a certain temperature (varying with species and acclimatized variety of bacterium). Some also require the presence of air. *Spirilla* grow only in liquid or semi-liquid substances. Different species of bacteria grow with different facility in various substances. Dead organic materials are their favorite soil, and the growth of microbes is the cause of decay and putrefaction; but, as we see in disease-producing species, some may grow in the living tissues of animals or plants, especially when such tissues are deficient in their inherent vitality.

Spores.—Nearly all bacteria, except spirilla, are capable, under some circumstances, of forming seeds or spores—extremely minute bodies—which retain their vitality for an indefinite time and when exposed to some conditions (such

* By Cohn.

† For Zopf's classification, which is more recent and scientific but more elaborate, *vide* Crookshank's Manual.

as drying or exposure to a temperature below that of boiling water) which would kill mature bacteria. Spores in favorable surroundings bud out into bacteria.

Other orders of Fungi also furnish some disease-producing species : a *Saccharomyces* (yeast or sprouting fungi) is the cause of "thrush;" *Hyphomycetes* (moulds) cause several skin diseases, and some of them have, in rare cases, invaded internal organs; *Actinomyces* causes a peculiar disease in cattle and man ; the doubtful organism of malarial fever may perhaps be referred to the *Myxomycetes.**

Innocent and Pathogenic Microbes.

To prove beyond all doubt that a certain disease is caused by a certain microbe, the following conditions † must be satisfied : (1) the microbes must be found in the blood or diseased tissues in all cases of the disease; (2) the microbes must be isolated and be artificially cultivated for several generations outside of the body ; (3) on introduction of the microbes so cultivated into the body of a susceptible animal the same disease must be produced ; (4) the microbes must be found in the blood or diseased tissues of the animal so inoculated.

All these conditions have been complied with in the case of several diseases of men and animals ; but such complete experimental proof is rarely possible, because, in some cases, of failure to cultivate the organisms outside of the body, and, in other cases, of the impossibility of finding animals which are susceptible to the particular disease, and experiments of this kind cannot be performed on men.‡

It is generally considered that if a certain microbe be constantly found in the blood or diseased tissues in cases of a given disease and not otherwise, the evidence that such microbe is the cause of that disease is all but conclusive, especially if the disease be proved to be contagious.

The term "pathogenic" (disease-producing) is generally restricted to those microbes which produce specific forms of

---

* Koch. Marchiafava is inclined to class it among the Protozoa.

† As laid down by Koch.

‡ It has often been proposed, but rarely permitted by any Government, that such experiments should be allowed on condemned criminals. There is nothing inhuman or improper in such a proposal. Men who had grievously injured their fellow-beings would most fitly expiate their crimes by rendering such services to all humanity.

disease when they grow within the body. Many of these microbes are very selective and exclusive as to the soil in which they will grow ; they often require very complex organic substances for their nutrition and restrict themselves to particular genera or even to single species of animals and sometimes to certain tissues only. Hence it is often difficult to cultivate some of them outside of the living body. Their most important character is the power which they possess of growing in the tissues of healthy animals and producing may be dangerous or deadly diseases in their hosts.

It is probable that many, if not all, pathogenic microbes may, under favorable conditions, grow outside of the body. The anthrax bacillus is known to grow readily thus in damp soil or on decaying organic substances. Koch found his cholera bacillus in the water of a foul tank at Calcutta, and the enteric bacillus has been found in the water of a well which had caused enteric fever.* But as yet our knowledge is very scanty regarding the life history of disease-microbes growing outside of the body. The geographical localization (endemicity) and seasonal prevalence of microbic diseases, that is, their being so much influenced by external conditions, are facts which somewhat favor the view that their specific microbes grow apart from as well as within the body.

Innocent or non-pathogenic microbes are found in immense variety and numbers in all decomposing organic substances; and different species often succeed each other in crops at various stages of decomposition, according as the particular kind of nourishing material which each prefers becomes exhausted. Organisms of this kind are always found in the nose, mouth and intestines of animals, without producing injurious effects. If introduced into healthy tissues or blood of living animals, they are speedily destroyed.

Ordinarily innocent septic microbes may, however, produce disease (though not specific communicable disease) in three ways : (1) they may produce poisonous alkaloids or extractives in decomposing articles of food ; (2) they may cause decomposition of ingested food in the alimentary canal with local irritation and perhaps absorption of poisonous products ; (3) they may grow in the discharges of wounds

* By M. Vignal in a case by M. Marty, *Acad. de Méd.*, Sept. 1888.

or ulcers, in abscesses, and in dead or dying portions of tissue, the decomposition-products produced by them causing local irritation or general poisoning.*

Susceptibility and Immunity.

Seed will not grow unless it be sown in suitable soil. It is a matter of common observation that large plants show preferences for particular kinds of soil and particular climates. Microbes show similar preferences, but many of them, especially pathogenic species, are more exclusively selective than larger plants in this respect. Thus some disease-microbes confine their attacks to one species of animal, for instance those of leprosy and cholera attack man only; while others, such as those of anthrax, not only attack animals of different species, but are known to grow very readily outside of the body. The electiveness of microbes for particular soils is shown by the preference which some of them † show not only for a particular species of animal but for a particular race or variety of one species and for particular individuals.

Many microbic diseases are *non-recurrent,* that is one attack produces immunity from further attacks of the same disease. The cause of this acquired immunity is not clear; two theories have been propounded to explain it—(1) that the first attack exhausts or destroys some chemical substance which was necessary for the growth of the specific microbes in the body; (2) that by the first attack some chemical substance is produced which is poisonous to,

---

* *May innocent microbes ever become pathogenic?* This is a controversial question which is of too great importance to be passed without notice. Koch and Klein, with many followers, strongly maintain that the thing is impossible. It is true that the very few cases in which it was supposed to have occurred have been disproved and that no experimental proof of its occurrence is forthcoming. But the readiness with which some microbes can be acclimatised to different conditions, such as great differences of temperature (*vide* Dr. Dallinger, *Pres. Address, Royal Microscop. Soc.,* 1887), the attenuation and intensification of the virulence of certain disease-microbes by Pasteur, the well-known fact of modification of type in different epidemics, the communicability of some microbic diseases among animals of different species, and the consideration that known microbic diseases must have been evolved in some such way should make us slow to accept this negation. Pasteur (*Comptes Rendus,* 1881) appears to believe that the disease-virulence of specific microbes is an acquired quality, and suggests that known diseases may have originated from innocent microbes.

† Measles, for instance, which is a mild disease in Hindus, more severe in Englishmen, and which has been terribly fatal among the Figians.

and prevents the growth of, the specific microbes.* Immunity can in some cases be artificially produced by inoculating with a mild variety of the disease; resistance against the severer forms of the same disease may thus be attained without much danger.†

Contagion.‡

The mere fact of a disease being proved to be contagious is evidence that it is of microbic or of parasitic nature. But, although all microbic diseases are contagious, they are contagious in different manners and with different degrees of facility. The microbes of diseases which affect the skin, such as small-pox and measles, are readily conveyed by the air, and such diseases are generally termed *infectious.* Those of diseases which affect the intestines, such as cholera and enteric fever, are present in the evacuations and may thus pollute water or food or the hands of attendants. Those of diseases which affect the lungs, such as tubercular phthisis and contagious pneumonia, may pass into the air from the lungs and be inhaled by other individuals.

---

* Sir J. Simon adopted the former view: "the susceptibility to the particular contagium is utterly exhausted from the patient, so that re-introduction of the same contagium will no more renew that patient's disease than yeast will excite a new alcoholic fermentation in any previously well-fermented bread or wine." He concludes that the inference is unavoidable that some special chemical ingredient of the body is exhausted. This theory is also supported by the analogy of crops of certain large plants which may exhaust a soil so that second crops of the same plants will not thrive.

The second or *antidote theory*, propounded by Klebs, is favored by Pasteur: "many microbes appear to give origin in their cultivations to matters which are injurious to their own development." Klein strongly supports this view, mainly because he considers the *exhaustion theory* disproved by the fact, which he has ascertained experimentally, that the microbes of anthrax and of swine-plague grow readily in an infusion of the flesh of animals which have been protected against these diseases by inoculation. But it may be pointed out that some chemical alteration is likely to occur in preparing the infusion, and that otherwise Klein's facts tell as much against the antidote theory as against the exhaustion theory.

† The supposition has lately been gaining ground that acquired immunity may be *inherited.* The fatality of measles when first introduced to Figi, where this disease was previously unknown, is thus explainable by the absence of inherited immunity. The diminution of virulence and gradual extinction of various diseases has been attributed to increasing inherited immunity.

‡ *Contagion* is here used synonymously with *infection* in a broad sense to signify not only communication of disease by immediate contact, but mediately also, through the air, by infected articles, such as clothes, and by water or food.

Those which affect the blood and deeper tissues, as anthrax and syphilis, are most readily conveyed by inoculation through a wound. Disease-microbes may also be introduced into man from living animals or in the flesh of animals used as food and in the milk of diseased animals.* Water, milk, and food may act as carriers for the microbes of various diseases.

It is tolerably certain that, under ordinary circumstances, most disease-microbes cannot live long floating in the air; for diseases which are propagated through the air appear to be only transmitted through a limited distance, and the effect of free exposure to air in destroying infection on clothes, &c., is well known. Some poisons, such as that of small-pox, last for a long time in the air and may be carried considerable distances, while others, such as that of plague, are easily destroyed and cannot be conveyed more than a very short distance by air. As already mentioned *spores* long resist agencies which would be destructive to mature microbes, and, under favorable circumstances, may retain their vitality for an indefinite time.

It is not known how long disease-microbes may live in water or earth. It is possible that these are sometimes, if not often, their natural soils or resting places, and that they thence invade animals: Pasteur found anthrax-germs in the earth where an animal that died of the disease had been buried twelve years previously. The possibility of contagion from virus thus preserved for a long period should not be overlooked; outbreaks of contagious disease which cannot be traced to previous cases may perhaps own some such origin.

---

* Toussaint produced tuberculosis in pigs by feeding them on the juice of flesh of tuberculous animals. The disease is probably communicable to man by meat and milk.

The most important microbic diseases of animals which are communicable to man are tubercle, anthrax, glanders, rabies (hydrophobia) and aphtha (foot and mouth disease). Rabies is always fatal, anthrax, glanders, and tubercle are usually fatal; aphtha is not generally a serious disease. No accurate statistics are obtainable. Mr. Mills' Report for 1885-86 shows that anthrax was very prevalent among cattle in Madras (mortality 84·3 per cent. of attacks). Aphtha was also very prevalent (mortality only 3·6 per cent). Twenty-seven fatal cases of tuberculosis and 10 of glanders were reported. More information regarding tuberculosis is desirable; it is a chronic disease in cattle and apt to be overlooked. Measures are greatly needed to suppress these diseases. Mr. Mills' and Messrs. Thacker and Hallen's books and the report of Indian Cattle Plague Commission may be consulted.

It is certain that flies may carry contagion. In the famine-camps in 1877 ophthalmia was so disseminated by them that hardly a child escaped. It is probable that they often propagate small-pox.

Domestic animals and men, who are not themselves affected by a disease, may act as carriers of it.

Acute contagious diseases, such as small-pox or dengue, are generally easily propagated and affect groups of individuals, each case acting as a focus round which other cases occur. Such diseases are commonly epidemic, and their contagious character is plainly evident. Chronic contagious diseases, on the other hand, such as tubercle or leprosy, are not so easily or rapidly propagated and develop slowly, so that they often appear to be isolated (*sporadic*) and their contagious character is not obvious.

The *dose* of a contagium would theoretically appear to be a matter of little importance, since even one single microbe may multiply indefinitely. Practically, however, it has been found * in some cases that a small dose inoculated produces only a local affection, a larger dose being required to produce the general disease. A large dose of weak or *attenuated* virus is also required to produce the same effect as a small dose of strong virus. The weaker effect of a small than of a large dose may be due to the slower multiplication of the microbes, the parent microbes being fewer, and perhaps to some enfeeblement of the brood in its struggle to obtain a footing in the body.

Endemics and Epidemics.

A disease which occurs at intervals in isolated cases is said to be *sporadic;* when it is always more or less prevalent in a place or community, it is said to be *endemic;* when it becomes largely prevalent for a time where it previously did not prevail, it is said to be *epidemic;* and when an epidemic is very widespread over a large tract or over the whole earth, it is said to be *pandemic.* Microbic diseases are nearly always endemic or epidemic in their incidence; this is a natural consequence of their contagious nature.†

---

* Watson Cheyne.

† In a generally excellent article on Infectious Diseases, Liebermeister (Ziemssen, Vol. I) lapses into the following curiously illogical statement: "As the majority of infectious diseases usually appear under an endemic or epidemic form, it is therefore quite fair to suppose that

The presence of endemic disease implies constant local conditions which favor it. The presence of epidemic disease implies at least the temporary existence of such conditions *and* the importation of the specific virus of the disease, unless it was already present.

What the local conditions are which favor the existence of endemics and epidemics, and how they may be mitigated or removed, it is the practical business of the sanitarian to examine.*

In the case of epidemics, moreover, where the disease did not already exist, it will be necessary to inquire into the methods of importation and spread. The first cases which occur are most likely to afford a clue, and no trouble should be spared in obtaining all possible information regarding them. Local insanitary conditions undoubtedly favor the spread of epidemics, and our first care should be to remove or mitigate them—we may thus prevent a disease from settling even if it be imported—but our second care, especially if local conditions are bad, should be directed to, if possible, prevent its importation and to isolate cases which occur.

The origin of epidemics of microbic disease is still in great part a matter of speculation. Why do diseases which are endemic or sporadic sometimes exhibit an increase of virulence and a tendency to spread and assume the epidemic form? Why do epidemics spread from certain centres in a wave-like manner being most severe and fatal at their first onset and gradually diminishing in intensity until they become extinct, except in endemic foci where they slumber? The starting point of epidemics has been attributed, with apparent probability, to the origin under favoring conditions of a brood of specific microbes possessing unusual vitality and virulence. Accidental hardy varieties in plants

---

any disease which we know arises endemically or epidemically belongs to the class of infectious diseases." This proposition is demonstrably untenable. It is evident that parasitic diseases may be endemic or epidemic. Physiological diseases also, arising from such causes as peculiarities in food, water, habits, or climate, or from injurious trades, may be endemic or epidemic according as their causes are permanent or temporary.

* For such inquiries an intimate knowledge of medicine, a just appreciation of the causes of disease, keen power of observation, and some logical acumen are desirable. Many reports of inquiries, by able officers, published in the Reports of the Medical Officer to the Privy Council and Local Government Board (England) may be taken as models for investigations of this kind.

and unusually vigorous breeds of animals arise occasionally in an analogous way. Swarms of locusts or moths or other insects come into being when conditions have been peculiarly favorable for their development, but not otherwise. The conditions which give origin to epidemic "sports" in disease-microbes are unknown; but the marked effect which climatic conditions have been observed to produce upon epidemic diseases points to the probability of such variations occurring during the growth of the microbes outside of the body. The greater intensity of an epidemic at its onset, and its gradual decline and extinction, are usually explained by the theory that the most susceptible individuals are first attacked, and later on those who are less susceptible and who therefore do not suffer so severely, and that, finally, the soil being exhausted, the disease dies out.* If this be true, the spread of an epidemic from a centre may be aptly compared to the growth of certain mushrooms in gradually widening circles ("fairy rings") according as they exhaust the soil of the nitrogenous nutriment which they require for their sustenance.

Epidemics sometimes appear to arise spontaneously, that is, no importation can be traced. This may commonly be owing to imperfect information, but it may occasionally be due to latent foci of the disease existing in a place. It is possible that the specific microbes or their spores may have existed locally in a dormant condition, or at all events without invading the human body. Thus the poison of plague appears to have been propagated by opening old graves, and anthrax has been disseminated among cattle from a grave seven years old.†

Epidemic diseases may be imported over and over again into a place; but, if local conditions be unfavorable, they will not extend.‡

Man can usually do little to alter climatic conditions, but he may often do much to alter other local conditions. He

---

* Pasteur thinks that the decline may be attributable to progressive "attenuation" of the virus by the oxygen of the air.

It may be suggested that such attenuation might result from growth at a high temperature in the body.

† Pasteur. Duclaux kept germs in a latent condition excluded from air for 20 years. Koch suggests that cholera microbes may ordinarily grow among decaying vegetation in such places as the *Sunderbunds* and thence invade man.

‡ This was the well-known view as to the influence of climatic conditions on the spread of cholera held by the late Dr. Bryden of Calcutta.

may keep the surroundings and interior of his dwellings clean and dry, thus arresting the local propagation of microbes; he may preserve his water and his food from defilement; he may strengthen his own body, so that it shall not be a ready prey for microbic invasion; he may isolate cases of disease and destroy the germs produced by them.

PREVENTION OF MICROBIC DISEASES.

Effective measures for the prevention of microbic diseases act—(1) by depriving the virus of a soil suitable for its growth, (2) by excluding it, or (3) by destroying it. Under the first head, we shall notice the removal of conditions which favor the growth of microbes without and within the body, and protection by inoculation; under the second, the isolation of the sick; and under the third, the use of disinfection.

External Conditions which favor Microbic Growth.

These have already been alluded to when treating of soil, houses, removal of refuse, water, food, &c. Climatic conditions, such as moisture, warmth, and stillness of air, are to a great extent unavoidable; but in climates where such conditions prevail, it is particularly necessary to pay great attention to dryness and purity of soil about houses, to cleanliness and free ventilation within them, and to the speedy removal of all waste matters and their disposal in the fields, where they may be disintegrated by harmless microbes and be assimilated as plant-food. As previously mentioned, little is known regarding the external life of such disease microbes as may live apart from the body; but it is certain that some may live apart, and, in the absence of definite knowledge, it is safest to assume that others may likewise, and to take all possible measures to discourage such growth.*

Bodily Conditions which favor Microbic Growth.

Feeble vitality of the living tissues undoubtedly predisposes to the invasion of microbes. Even ordinary septic microbes may attack tissues which are dying or whose

* In connection with this point see a suggestive article in *The British Medical Journal*, January 21, 1888, on "The Relation of Putrefaction to Infectious Diseases."

vitality is at a very low ebb. Previous good health and strong vitality do not, however, afford much resistance against the attacks of all pathogenic microbes, except by preventing their lodgment in the body. If the skin and mucous lining of the respiratory and digestive tracts be in a healthy and unbroken condition, most disease-microbes may be brought into contact with them over and over again without being able to effect a lodgment. On the other hand, a scratch or ulceration of the skin, in a previously healthy individual, may admit the microbes of many diseases, such as syphilis, tetanus, &c. Ulcerated conditions of the intestinal mucous membrane, such as are extremely common in India, produced by intestinal parasites or otherwise, may also admit various microbes * into the blood or tissues.

Inflammatory conditions of the respiratory mucous membrane, or inactivity of respiration due to deficient exercise or previous disease, may prevent the inhaled microbes of tubercle, pneumonia, &c., from being thrown off.† There is some evidence that chemical alteration of the normal secretions, or of the blood or tissues, may dispose to microbic infection,‡ and there is no doubt that *inherited* weaknesses of certain organs may do so.

It is thus apparent that physiologically morbid states do predispose to the reception of microbic diseases, and that preservation of the general health is one of the best safeguards against them.

Protection by Inoculation.

The subject of non-recurrent diseases and acquired immunity has already been noticed. Immunity from such diseases may be artificially procured by producing a mild form of disease such as will occasion little or no danger to life. The theory of protective inoculation, such as vaccination to prevent small-pox, is founded upon this fact. A serious objection to inoculation, however, apart from

---

* Including *actinomyces* and even *mycelial fungi.*

† One microbic disease may pave the way for another, as in "compound gonorrhœal infection," investigated by Dr. Bumm, in which the *coccus* of gonorrhœa renders the mucous membrane assailable by *pyogenic* microbes.

‡ For instance Koch found that his cholera bacilli were destroyed by the naturally acid gastric juice but passed through the stomach unaffected when its contents were neutral or alkaline.

its possible dangers in practice, is that it necessitates the preservation and multiplication of disease poisons.

Protection against a non-recurrent disease may thus be obtained by inoculation with (1) the *attenuated* virus of the same disease, (2) the virus of a closely similar disease, (3) a *small quantity* of the active virus of the same disease, (4) the chemical products of the virus of the disease without the actual living organisms. *Attenuated virus* is produced by various artificial methods of cultivating a virus.* By inoculation of microbes so attenuated a mild variety of the disease is produced which, without being itself dangerous, may confer more or less complete immunity against attacks of the virulent disease. If strong virus be afterwards inoculated into an animal thus protected, it either fails to cause any disease or produces a modified mild form of the disease. To obtain complete immunity it may be necessary to inoculate several times with virus of increasing intensity.† The immunity thus obtained does not necessarily last for life, but may become lessened by lapse of time.

Similar virus, that is, the microbes of a similar disease, may cause immunity from certain diseases. It is thus that the inoculation of cow-pox (*vaccination*) produces immunity from small-pox in man.‡

It has been attempted to explain the immunity thus obtained by assuming that the diseases are identical, that is, that cow-pox is modified small-pox. But all attempts hitherto made to communicate small-pox to cows (and thus produce cow-pox) have failed. It is probable, from their resemblances, that these diseases have had a common origin; but now at all events they are clearly distinct diseases. Not only can small-pox not be transformed into cow-pox by inoculation into the cow, but cow-pox has been

* For instance attenuation (weakening) may be produced by exposure of cultivations of the microbes to air (Pasteur), to antiseptics (Chamberland and Roux), to a high temperature (Toussaint), to compressed oxygen (Chauveau), or by growing them in the living bodies of certain species of animals (Pasteur). Attenuated virus may be restored to its former virulence or even be increased in virulence by growing it in certain other animals (Pasteur). The microbes of fowl-cholera, swine-plague, anthrax, and several other diseases of animals have been thus attenuated.

† Pasteur.

‡ Heube and Kitt are thought to have shown experimentally that the four diseases, cattle-plague, swine-plague, rabbit-septicæmia, and fowl-cholera, are thus mutually protective, that is, an animal which has suffered from one of those diseases is proof against the others.

transmitted (by vaccination), for innumerable generations of its microbes through man, without showing any tendency to assume the characters of small-pox.*

A small quantity of virus may apparently, in some cases, produce the same effect as *attenuate* virus.†

The chemical products of a virus, after the microbes had been killed by prolonged heating, have been found, in some cases, to produce a refractory condition, in the same way as the inoculation of attenuated virus.‡ If this method of protection proved to be generally applicable, it would be the safest and most perfect of all systems of inoculation; for the dose might be exactly regulated and the poison could not be multiplied in the body. Further researches on this and other points connected with protective inoculations must, however, be awaited.

Isolation of the Sick.

The advantage of limiting a communicable disease by isolating persons suffering from it is obvious and has been recognised from ancient times. But isolation is not equally useful or practicable in all cases of communicable disease; and the manner and degree in which different microbic diseases are communicable must be taken into account in devising measures for their limitation. Some, like small-pox, whooping-cough, dengue, and mumps, are easily and usually communicated, for some distance, through the air, as well as by contact of persons or infected articles. A second group, containing diseases, such as tuberculosis and pneumonia, appears to be less readily communicable. A third group, comprising cholera and enteric fever, is communicable rarely, if ever, through air, but usually in drinking-water and probably in food; while a fourth group of diseases, such as syphilis, rabies and probably leprosy, appears to be communicable only by inoculation. Malaria

---

* Professor Fleming, one of the highest living authorities on the diseases of animals, has expressed his belief that small-pox and cow-pox are quite distinct.

† This has been found to be the case in "charbon symptomatique" investigated by Arloing Cornevin and Thomas.

Pasteur thinks that the reduction in intensity of the virus of *rabies* by his method may be attributable to diminution of *quantity*.

‡ Salomon and Th. Smith thus protected animals against American swine-disease.

stands by itself, as it cannot, in the course of nature, be communicated from person to person.*

It is in the case of the first of these groups, which contains what are commonly known as "infectious diseases," that isolation is particularly efficacious and desirable. It is so to a lesser degree in the second group. In the third group, other measures, such as disinfection, cleanliness, and preservation of water and food from infection, are most useful, isolation being unnecessary if they are strictly attended to. In the fourth group isolation is useful; but, owing to the chronic nature of some inoculable diseases, it may be difficult or impracticable to enforce it. Individuals may generally, however, protect themselves from such diseases by avoidance of direct contact with the affected, especially of such contact as may lead to inoculation at any abraded or mucous surfaces.

It is evident, therefore, that isolation is most practicable and useful in those *acute* diseases which are ordinarily communicated by *aërial infection.* But the best manner of carrying out such isolation is not always apparent. Is all communication with sick persons and their households to be cut off? Are travelling and commerce by sea and land to be hampered or arrested by the restrictions of *quarantine?* Are the sick to be secluded, under medical care, in their own houses; or are they to be removed to special hospitals?

The first-named method of isolation by "boycotting" would, in most cases, be inhuman and barbarous, nor would it often be possible to carry it out effectively.

Quarantine, in the modern acceptation of the term, means arrest of communication with infected places except under certain restrictions. These usually consist in detaining healthy travellers for a specified time after their departure from an infected place, and travellers, among whom the disease has broken out for a specified time after the occurrence of the last case of disease among them, on board ship or in a place (*lazaretto*) set apart for the purpose. The time of quarantine should cover at least the longest known period of incubation of the disease. Merchandise is also, if

* We allude here only to the habitual manner in which each disease is communicated—many diseases, as we have seen, being capable of communication in more than one way. Rare diseases produced by invasions of fungi which ordinarily grow outside of the body may be classed with malaria.

admitted, sometimes subjected to some process of disinfection, and the importation of particular articles, such as rags, may be prohibited.

In theory quarantine would seem to be an effective way of excluding communicable diseases; but actually it has nearly always failed to do so. It was practised extensively during the great epidemics which devastated Europe during the middle ages; but it signally failed to check them. It has, in more recent times, as constantly and conspicuously failed.*

The reasons for such failure are numerous. The period during which infection may last being much longer in some diseases and of more uncertain length than the period of incubation, persons among whom the disease has occurred, and possibly those who have been kept in contact with them, as the healthy are with the sick during ordinary quarantine, may carry infection for a longer period than can well be covered by quarantine. Quarantine usually interferes with food supplies, and it may thus cause privation and predisposition to disease; and by checking commerce it alters prices and affords strong temptation for its own evasion. The police or troops employed as quarantine guards cannot always be depended upon; even if reliable, it is difficult for them in all cases, impossible in most, to arrest all communication, and they themselves are exposed to hardship and are likely to contract and spread the disease.† The imprisonment of healthy and sick together in a *lazaretto* is not only barbarous, but tends to keep the disease alive. Money is thus wasted on measures which are worse than useless when it might be usefully employed. These are some of the direct evils of quarantine. Indirectly its effect is equally pernicious: disease is concealed owing to the fear of quarantine; when it is imposed, the people, relying on the ostentatious measures taken for their security, encourage disease by neglecting local sanitation, and give way to panic when the epidemic breaks through their

---

* The Sanitary Commissioner with the Government of India, alluding to quarantine, which was tried in 1872 in the hope of protecting certain cantonments from cholera, wrote: "in no single instance is there the smallest reason to believe that it was productive of any good." Quarantine restrictions "set the people against everything that is done under the plea of their public health." "As a consequence cholera cases were concealed."

† Cholera was said to have been carried in this way in Egypt in 1883.

futile "sanitary cordon" of police and soldiers. Microbes must be met with other weapons than bayonets.

Land quarantine may therefore be regarded as impracticable, and least likely to be efficient in populous places, where presumably it is most needed. Sea quarantine may be useful in some cases if administered intelligently, but it scarcely concerns us here. In any case it should not be imposed for a longer period than the longest incubation-time of the disease, after sailing from the last infected port or after the occurrence of the last case of the disease on board; and, for reasons given above, it should by no means supersede or dispense with the usual precautions of medical inspection.*

Though quarantine, as such, is inadmissible, yet much may be done by individuals and by bodies, such as troops or students, subject to discipline, to *avoid infection*. Thus the public should be warned of the prevalence of communicable disease in particular localities, and persons under control may be prevented from visiting such places. When epidemic disease exists, movements and assemblages of population should, as far as possible, be restricted, and marches of troops, fairs, and pilgrimages be prohibited, or at all events carried out with special precautions, and schools may be closed with advantage in some cases.

When an infectious disease breaks out in an army or in a body of workmen or prisoners, it may occasionally be possible to resort to the plan of isolation by groups, such as is practised in the extirpation of cattle diseases. The body is subdivided into a number of smaller groups, which are kept separate. When any of these groups have been free from the disease for a period equal to its longest incubation-time, they may be passed as safe and not likely to spread infection.

The most efficient and practical of the isolation methods for the prevention and extirpation of communicable disease

---

* The local rules for quarantine and medical inspection of shipping are contained in Proceedings of Madras Government, Marine Department, 24th May 1879, No. 280.

The writings of Dr. Thorne Thorne and Dr. Buchanan, M. O. of the Local Government Board during the past five years, express and fully justify the English view regarding the great value of sanitary measures, as opposed to sea quarantine, in preventing the spread of cholera. Professor Pettenkofer and Mr. Shirley Murphy ably supported this view at the Vienna Hygiene Congress of 1887.

is, however, the separation of the sick in hospitals or in their homes. But the efficiency of this method depends very largely upon the co-operation of the people themselves.

The first essential is that immediate notification of all cases of infectious disease should be given to the local sanitary authority.* This authority should then be prepared to adopt immediate measures for the seclusion of patients at home or for their removal, with due precautions, to a properly appointed special hospital. Immediate notification of all cases of infectious disease may enable the sanitary authority not only to isolate the sufferers so as to prevent their becoming centres for the dissemination of the disease, but also possibly to trace the original source of the disease and take effective measures for its suppression. Wealthier patients may be effectively isolated and treated in their own houses; but in the case of poorer patients it may be difficult or impossible to secure proper isolation and treatment without removal to hospital. Poor people can not only be better isolated in hospitals than in their own homes, but they obtain greater comfort while they are sick. When they object to such removal, efforts must be made to isolate them as well as circumstances will allow.

The provision of special hospitals for infectious diseases at all large centres of population is an important duty of sanitary authorities. Space will not admit of any details in this place about the construction and administration of such institutions. One great difficulty regarding them is to secure a well-isolated site conveniently near the population for which the hospital is intended; a second one is (especially in the first class of communicable diseases: those readily transmissible by aërial infection) to prevent dissemination of the disease by servants and attendants.† The permanent buildings of infectious hospitals need not be large; but sufficient space should always be prepared for the erection of temporary sheds to provide for epidemics.

---

* Several English towns have adopted compulsory notification (under the Act of 1882). It is still a moot point whether such notification may best devolve upon the medical man in attendance or upon the householder. Section 368 of the Madras Municipal Act of 1884 requires such notification to be given by all medical practitioners. The advantage of good notification and isolation has lately been well exemplified at Leicester, where, although there has been to some extent a strike against vaccination, small-pox has been arrested in this way.

† Mr. Power's report on the Fulham Small-pox Hospital has shown the danger of locating such institutions *in* towns.

The contagious wards attached to the Madras General Hospital are good examples for such buildings. Special vehicles must, of course, be provided for the removal of persons suffering from infectious diseases.

For the isolation in their houses of persons suffering from infectious diseases, the following points require particular attention *:—

(1) All unnecessary furniture and clothes should be removed from the room.

(2) A sheet soaked in a disinfectant, such as a 1 in 20 solution of carbolic acid, should be hung over the door as a curtain.

(3) The windows of the sick-room should be kept open as much as possible.

(4) The attendants should, if possible, be selected from among persons who have already had the disease, or have been exposed to it without contracting it. They should avoid communication with other persons unless they have previously washed and changed clothes. All unnecessary articles, including change of clothes, should be removed from the room which the attendants habitually occupy. The clothes which they wear in the sick-room should be non-absorbent and readily washed. They should dip their hands in a disinfectant liquid (corrosive sublimate 1 in 1,000 or carbolic acid 1 in 20) on leaving the room. Their soiled clothes should be immersed in a disinfectant solution and afterwards boiled.

(5) Visitors should not be allowed to enter the room; but, if necessary, should only speak to the sick person through the curtain at the door or through a window. Other residents in the house should avoid contact with the attendants. Children, if they remain, should not be allowed to go to school or mix with other children.

(6) Excreta and remains of food should be received in a vessel containing some strong disinfectant and be afterwards buried.

(7) Soiled linen should be placed in a disinfectant solution and be afterwards boiled.

---

* The recommendations of the Soc. of Med. Off. of Health, Dr. G. Wilson (*Hand-book*, 6th edition, p. 500), and Mr. Shirley Murphy (*Infectious Diseases*, p. 41), may be referred to.

(8) When danger of infection is believed to have ceased, the patient should be well washed, bathed with a disinfectant lotion, and have a complete change of clothes before he is allowed to mix with others.

(9) The room must be thoroughly disinfected after the patient has vacated it.

(10) In case of death, the body should be completely enveloped in a sheet soaked in corrosive sublimate or strong carbolic solution and be buried or cremated as soon as possible.

It is scarcely necessary to remark that it must, even if the patient and family give the most willing assistance, be extremely difficult to carry out all these precautions thoroughly in a private house, and that even in a hospital it may be possible to do so only partially. Sanitary officers should, therefore, endeavour to induce patients and their friends to consent to their removal to hospital, where they will probably be better cared and be less dangerous to their families and neighbours than if they remained in their own homes. It must always be borne in mind, however, that even very imperfect and incomplete isolation is better than none, and may do a good deal in checking the spread of communicable diseases.

The periods of incubation and infectiousness are manifestly of much importance in considering measures for the suppression of infectious diseases. The following statement shows the period of incubation (time from reception of poison until the disease appears) and the duration of infectiousness or contagiousness of some of the most important microbic diseases so far as they are known. Practically "the power of imparting infection begins with the first symptom and lasts until the patient has absolutely recovered," that is, until "all special appearances of his disease shall have disappeared." *

* S. Murphy *loc. cit.*

Disease.	Incubation.	Infection.
Small-pox	12 days	6 weeks usually.
Chicken-pox ...	10 to 19 days	3 " "
Measles	8 to 12 days or more ...	4 " "
Dengue	3 days, may be 5 or 6 ...	2 " "
Mumps	10 to 22 days	3 " "
Whooping-cough ...	4 to 14 days	8 " "
Influenza	A few hours	1 or 2 weeks.
Gonorrhœa... ...	4 days usually, may be 1 to 8 days.	3 weeks or longer.
Diphtheria	1 to 8 days	6 weeks usually.
Relapsing fever ...	A few hours to 12 days, commonly 5 days.	4 " "
Enteric fever ...	5 to 21 days, commonly 11.	6 " "
Cholera	A few hours to 5 days ...	2 " "
Malaria	A few hours to months, often 12 days.	Not transmissible from person to person except by transfusion of blood.
Plague	2 to 5 days	3 weeks or more.
Tuberculosis ...	3 weeks	Indefinite.
Syphilis	6 weeks	Indefinite.
Leprosy	2 years or more.	Always.
Rabies	14 days to many months, commonly 6 weeks.	(?)

Disinfection.

Disinfection, employed with or without isolation of the sick, is an important aid in the suppression of microbic diseases. By it the germs of disease are either destroyed or their multiplication is prevented. Destructive, or germicide, disinfectants are of course most effective; but weaker inhibitive disinfectants may be of great use, and can often be employed (as in inhabited rooms or for medicinal purposes) where destructive agents may be inadmissible.

The spores, or seeds, of microbes are much more resistant than the developed microbes, and resist agents which readily kill the latter. Certain microbes (such as all *spirilla* and Koch's "comma-bacillus") are not known to form spores; and such organisms are more easily extirpated than those which may exist in the "resting-form" of more resistant spores (such as small-pox *cocci* * or anthrax *bacilli*).

* "Spore forms may be suspected in diseases, such as small-pox, the contagia of which long retain their virulence, even in the dry state."—*Koch.*

*

Disinfectants may be divided, according to their power, into three classes :—

(1) Destructive to spores.

(2) Destructive to microbes, but not killing spores.

(3) Inhibitive or antiseptic, preventing multiplication of without destroying microbes.

Another useful division of disinfectants is into (1) gaseous or volatile, and (2) fixed, the former being particularly suitable for disinfection of air.

A thoroughly reliable disinfectant for general use should be able to destroy spores in a short space of time. In inhabited places, it is impossible to employ aërial disinfectants of sufficient strength for this purpose; but, by employing fixed disinfectants for floors, walls, and most solid articles, combined with aërial antiseptics, even inhabited rooms may be disinfected; for such microbes as are not destroyed in the air sooner or later subside. Little is known as to the effect of disinfectants upon non-microbic poisons, such as leucomaines, or chemical products of microbic growth, though it is probable that some disinfectants may have a destructive influence upon them; but the action of many disinfectants upon microbes and their spores has been determined experimentally.*

The following are the most useful disinfectants :—

1. *Disinfectants destructive to spores.*

Moist heat over 100° C. (112° F. or boiling point of water) applied for 15 minutes.†

Chlorine gas, at least 1 per cent. in moist air. This disinfectant is injurious to clothing and metallic articles. To produce it in sufficient quantity for complete destruction of all spores, 15½ lb. of bleaching powder and 22 lb. of hydrochloric acid should be mixed for every 1,000 cubic feet of air space, and articles to be disinfected should be moistened.

Chlorine water, *Iodine* water, *Bromine* (2 per cent.) water, are also effective.

---

* By Koch, Gaffky, Fischer, and others. H. F. Parsons and Klein (Rep. Med. Off. Loc. Govt., Bd. 1884) have also made numerous experiments on disinfection by heat.

† It would be necessary to employ *dry heat* at 140° C. for three hours to produce the same effect.

Mercuric chloride (corrosive sublimate). A solution of one part of this salt in 1,000 of water (distilled water if obtainable) has a rapid and certain destructive effect upon the spores of microbes. One part in 5,000 is generally quite sufficient.*

This solution may be employed in the form of spray for disinfecting articles which cannot be immersed in it, or it may be painted on with a brush. Corrosive sublimate has the advantage of being cheap, considering the small amount which suffices; but it has the disadvantage of being very poisonous.

Carbolic acid in strong solution (1 in 20) is not certainly, though generally, fatal to spores within 24 hours.

Potassium permanganate in very strong solution (1 in 20) † is effective, but inapplicable owing to its color and expense.

2. *Disinfectants destructive to microbes but not to spores.*

Heat: dry heat of a little over 100° C. for 1½ hour; moist heat of considerably less than this degree. The heat of the sun is probably often sufficient to destroy disease-microbes.‡

Drying destroys some organisms (such as Koch's "comma-bacillus" or spirillum).

Exact experiments are still wanting to determine what chemical disinfectants will destroy microbes and not their spores; but it may be assumed that those disinfectants which readily diminish the vitality of spores are destructive to microbes. The following list § is based on that assumption:—*Ferric chloride* (5 per cent. solution), *Bleaching powder* (5 per cent.), *Copper* and *Zinc sulphates* (5 per cent.), *Boracic acid* (5 per cent.), *Quinine* (2 per cent.), *Iodine* (1 per cent.), *Carbolic acid* (2 to 4 per cent.), *Mercuric chloride* (1 in 10,000 to 1 in 20,000). These agents act with different degrees of rapidity: Bleaching powder, Quinine, Iodine,

* A piece of bright copper, immersed in some of the solution for half an hour, should become silvery on the surface if the solution is strong enough.

† *Condy's fluid* is very much weaker.

‡ Henry found 60° C. (140° F.) sufficient to destroy the virus of vaccinia, and Klein found 85° C. to destroy that of scarlet fever.

§ From Koch.

Carbolic acid (4 per cent.), and Mercuric chloride having effect within 24 hours.

3. *Disinfectants which arrest the growth of microbes without destroying them.*

The following list shows the quantities of various disinfectants, in parts per million of dilution, required to prevent the growth of microbes under otherwise favorable conditions. *Mercuric chloride* 3, *Allyl alcohol* 12, *Oil of mustard* 30, *Hydrochloric acid* 590, *Salicylic acid* 666, *Potassium permanganate* 714, *Carbolic acid* 1,200, *Quinine* 1,600.* It will be seen that mercuric chloride is by far the most powerful in a very dilute state, though allyl alcohol and oil of mustard also possess remarkable power in preventing the growth of microbes. Oil of turpentine and several other essential oils are also inimical to microbic growth. Much more dilute solutions than the above possess some power in impeding, though they do not completely arrest such growth. Thus, one part per million of mercuric chloride, 3 parts of oil of mustard, or 300 of carbolic acid, have some effect in this way.

Practical Disinfection

has now to be considered briefly. Our remarks on this subject may be conveniently sub-divided as they relate to disinfection (1) of inhabited rooms, (2) of vacant rooms, (3) of persons, (4) of clothing, &c., (5) of effete materials from the sick, (6) of dead bodies, (7) of sewers, cess-pits, latrines, &c., (8) of food and drink.

In the disinfection of inhabited rooms, as of other places, the great importance of cleanliness and free ventilation and admission of light, as adjuvants, need scarcely be further alluded to. If the room is actually occupied by a sick person suffering from any readily communicable disease, attention must mainly be directed to prevent the spread of infection. If the disease be of a kind easily infectious through air, special care must be taken to isolate the sufferer as previously explained. Emanations from his skin may be disinfected and be prevented from passing into the air by some local application, such as carbolized oil. The floor of

---

* This list is taken from Koch's record of experiments with anthrax bacillus spores.

the room may be painted over with a solution of corrosive sublimate (1 in 1,000): this may also be applied to any horizontal surfaces or places likely to harbour dust. Aërial disinfection must necessarily be only very partial and be limited to impeding the growth of microbes by diffusion of volatile disinfectants, such as oil of turpentine or of peppermint or carbolic (1 in 20) spray.

Vacant rooms should, however, be thoroughly purified. Sulphur fumigation, as commonly used, is useless. Chlorine fumigation may be employed, the air being rendered damp by a vessel of boiling water in the room and all apertures being closed for some hours. Chlorine, however, if sufficiently strong to be effective, is likely to damage many articles, and has not much penetrating power. Mercuric chloride is better and more manageable. Its solution may be painted over all parts of the room and furniture, or be applied in the form of spray. This salt, being easily volatilized, may also be effectively employed as a fumigating agent in the following manner.* The windows and other apertures being closed, 50 or 60 grammes (about 1½ to 2 oz.) of corrosive sublimate (less than this for a small room) are sprinkled upon an iron or earthen dish placed over a glowing fire, and the room is locked for three or four hours. It is then entered by a person whose nose and mouth are covered by a cloth to prevent his breathing the fumes, and the windows being rapidly opened, the room is left for some hours longer. It is afterwards fumigated with *sulphur* used in the same way as the corrosive sublimate. The latter is thus rendered harmless (forming mercuric sulphide). In the absence of better disinfectants the room may be painted abundantly with limewash, which must be made with *freshly burnt* quicklime. A good and easy method, when it can be employed, of disinfecting floors is to spread dry straw over them and set fire to it.

For disinfecting the bodies of persons, soap, especially soft soap, is an agent of some power. Complete disinfection of the surface may be secured by brushing a solution of corrosive sublimate (1 to 1,000) all over the body, including the hair, and after a few minutes washing all over with soap and warm water.

* Proposed by König of Gottingen. *Vide* Dr. Elliston in *British Medical Journal*, 30th October 1886.

Disinfection of clothing is very important. The infection of diseases, such as small-pox and other eruptive fevers, clings to clothing, especially woollen articles, for a long time and is thus often transported and disseminated. Sanitary authorities should see to the proper purification of infected clothing and prevent its being sent to washermen or laundries. Happily the disinfection of clothing is a simple matter. It suffices to boil it in water for half an hour. Immersion in a solution of corrosive sublimate (1 in 1,000 or even 1 in 5,000) may be employed instead of boiling. Articles which would be damaged by wetting or boiling may be disinfected by dry heat, in places where a suitable disinfecting chamber is provided. For thick bulky articles, such as blankets, rezais, and mattresses, which are not rapidly penetrated by heat, exposure to super-heated steam (in a specially made chamber or cylinder) is the most rapid and effective method of disinfection.

Discharges from the sick, soiled rags, &c., should be received in vessels containing a sufficiency of some strong disinfectant, such as crude carbolic acid, ferric chloride, or mercuric chloride solution. In the absence of these, dried earth may be used as an absorbent for them, this being, as soon as possible, cremated, or else buried in a deep trench. Soiled straw of bedding, old worthless clothes, &c., should be wrapped in a sheet or bag soaked in disinfecting solution, and be taken out and burnt. The disinfection of all discharges from the bowels, and of clothes or bedding soiled with them, is particularly important in cholera, enteric fever, and dysentery, but it should on no account be neglected in small-pox and similar diseases.

The body of a person who has died of a readily contagious disease should be completely enveloped in a sheet wetted with strong disinfectant solution, and be cremated or buried with the least possible delay. If there be any discharges flowing, dried earth or chaff mixed with some disinfectant should be placed under the body.

Well made and well kept latrines and sewers should not, as a rule, be in need of disinfection. During epidemics, and when it is known that they have been used by persons suffering from readily infectious diseases, it may be useful to employ disinfectants in them. The cheaper disinfectants are the most suitable. Mercuric chloride is probably not the best for this purpose, as sewage contains a large proportion of substances which precipitate it. Crude

carbolic acid, ferric chloride, or the ordinary sulphates of iron, copper, or zinc in strong solution may be used with advantage. After flushing with disinfectants and cleaning latrines, all surfaces liable to be soiled, especially if they be of wood, brick, or other absorbent material, may usefully be painted with tar. In the absence of such disinfectants as those above named, latrines, empty cess-pits, &c., may be purified by burning a quantity of straw in them.

It is certain that some, and probable that other infectious diseases may be communicated in food or drink. Recent and thorough cooking is a certain disinfectant and the best safeguard against such communication. At all times, but more especially during epidemics, it is a wise precaution to cook or boil all articles of food or drink which are not entirely above suspicion, and not to keep them after cooking in any place where they may be exposed to infection by man or by domestic animals or insects or dust. Boracic acid is the most suitable chemical disinfectant for food, as it is not poisonous.

Classification of Microbic Diseases.

The following groups of microbic diseases may be distinguished.*

Miasmatic Diseases,† due to microbes, which multiply outside of the body (but may also multiply within it). These diseases are not generally communicable from person to person directly. Isolation of the sick is, therefore, of comparatively little importance; but cleanliness and attention to other local conditions, such as dryness of soil and purity of air, water, and food, and disinfection of bowel

* The official division of these diseases as adopted by the Registrar-General in England is as follows:— (1) Miasmatic, (2) Diarrhœal, (3) Malarial, (4) Zoogenous (derived from lower animals), (5) Venereal, (6) Septic.

† Liebermeister thus distinguishes between *miasmatic* and *contagious* diseases. Miasm propagates itself outside of the body; it originates from without, and being taken into the body can produce a specific disease, but it cannot spread the disease from person to person. Contagium originates and multiplies in the body of the sick person. Malarial fever is purely miasmatic, small-pox purely contagious; but the poisons of other diseases may multiply outside of the body and inside of it also, as anthrax. Cholera has little or no tendency to spread from person to person, but it must be imported; it is therefore probable that its poison multiplies readily outside of the body and that it may be classed with enteric fever, and dysentery among *miasmatic contagious diseases*.

discharges in cholera, dysentery and diarrhœa, are of the greatest use in preventing them. Malaria, cholera, some forms of dysentery and diarrhœa, enteric fever, and beri-beri belong to this group. Anthrax and tetanus may also be included in it, though the former is easily inoculable from person to person.

Aërial Infectious Diseases are readily communicable from person to person for a short distance through the air as well as by direct contact or by infected articles. Isolation of the sick, combined with disinfection, is all important in the suppression of these diseases. One attack, as a rule, protects against a second attack of the same disease. Small-pox, measles, dengue, contagious pneumonia, relapsing fever, and plague belong to this group. Tuberculosis is the only important *chronic* disease which appears to be often communicable through the air; it is also included among inoculable contagious diseases.

Inoculable Contagious Diseases are usually communicable only by contact at a mucous or abraded surface. Owing to the chronic nature of some of these diseases isolation is often difficult if not impracticable. Tuberculosis, leprosy, and syphilis are three important chronic diseases belonging to this group. Other diseases which may be classed in it are gonorrhœa, contagious ophthalmia, erysipelas, septicæmia, rabies and anthrax. Isolation is generally practicable and useful in these. Erysipelas and ophthalmia may be communicated through the air for a short distance in confined and ill-ventilated places.

Microphytic Skin Diseases, of which ring-worm is a common example, are usually communicated by contact direct or mediate. Isolation may be necessary especially in the case of children; but local disinfection and treatment are sufficient in ordinary cases to prevent spread.

A few of the most important diseases of this class must now receive separate, though necessarily brief, notice.

Malaria.

Malarious diseases are by far the most important of all diseases in India and in most tropical and many temperate countries. The mortality caused by malarial fevers is enormous; but even this great destruction of life is not the largest evil wrought by malaria. For every death which occurs there are many attacks, representing an incalculable

amount of suffering, loss of working power, individual and racial deterioration.*

"The great universal and constant destroyer fever"† accounted for three-and-a-half millions of the registered deaths in British India in the year 1885. Though registration is still very imperfect, this is perhaps about the true number, omissions being probably made up for by the inclusion of other diseases under the head of fever. The ratio of deaths from this cause per 1,000 of population was in the North-West Provinces 25·4, in Central Provinces 19·35, in Punjab 18·4, in Bengal 15, in Bombay 14·1, and in Madras 7·7. In the North-West Provinces, where registration appears to be better than in other provinces, in 1886 the total rural death-rate was 32·05 and the fever death-rate 27·58. Appalling as these figures are for great provinces, the fever death-rates for certain districts are necessarily much higher. Thus we find that in the Collectorate of Broach (Bombay), in 1887, the fever death-rate reached 33·39, and, in 1886, in Julpigoree (Bengal) it was 31·01, and no less than 79 per cent. of the children in one thana of this fever-stricken district were found to suffer from enlarged spleen. "The district reports repeat the same melancholy story of weakness, anæmia, enlarged spleen and liver, debilitated constitutions, pulmonary and enteric complications, and other sequelæ."‡ For the five years 1883–87, the registered deaths from all causes in Madras districts were only 21·08 per 1,000, those from fever being 7·82, cholera 1·49, small-pox 1·22, and bowel-complaints 0·96. In 54 municipal towns of Madras, where registration is much better than in the districts, the death-rate in 1887 was 31·2 and the fever death-rate 7·1. These statistics suffice to show the enormous and preponderating importance of malaria as a cause of death (and sickness) even in the Madras Presidency where it is least prevalent.

Local Conditions which favor the production of malaria are well known. It is hardly necessary to adduce proofs that it is an emanation from the soil. A soil containing some organic matter and moisture, warmth and air are

---

* The mortality "is a mere trifle compared with the ravage fever commits in sapping the strength and vigour of the country ... fever destroys the life of the country ... the deaths must be multiplied by 50 or 60 to give the attacks."—*Florence Nightingale. Life and Death in India,* 1874.

† Army Sanitary Commission.

‡ Bengal Administration Report, 1886.

essential.* But some soils, where all these conditions are present, are not malarious; it is, therefore, probable that the soil must be infected with some particular microbe or microbes which are the true cause of malaria. Permeable soils containing much organic matter are notoriously the most malarious. The geological nature of the soil, except in so far as it influences its physical condition, appears to have little or no effect, but peat is (chemically) antagonistic to malaria. Altitude above the sea-level checks its development, and it is rarely produced at a greater height than 4,000 feet above the sea. It may, however, drift to much greater height with currents of air flowing up mountain valleys, and it may be carried for a considerable distance horizontally by winds. The poison is most intense close to the surface of the soil, and even a slight elevation above the surface may diminish or prevent infection. Very limited and localized causes such as accumulations of decaying refuse, growth of rank jungle, decomposing grain or other substances in a ship's hold, dampness of soil caused by leakage of water by irrigation or by blocking of a drainage channel, may cause outbreaks of malarial fever in the immediate vicinity. Disturbance of a malarious soil is certain to cause evolution of malaria, and should especially be avoided at times when fever is most prevalent in the locality.

The occurrence of malaria largely depends upon the moisture of the ground and its seasonal prevalence is usually well marked. Too much water and too little check its development. In some dense jungles, such as those of South Canara, the healthiest time is during and immediately after heavy rains; in places with a more moderate rainfall fever is most prevalent soon after rain; while in comparatively dry and bare regions, such as the Deccan, the rainy season is the most feverish, and the amount of fever is directly proportionate to the rainfall.† Irrigation,

* Tommasi-Crudeli (*Il clima di Roma*, 1886) states that malaria requires for development a temperature not lower than 20 C. (68° F.), moderate humidity, and contact of air with the infected soil. Absence of any one of these conditions prevents development of malaria. At times a natural suspension may occur, as from cold, or drought, or exclusion of air from soil by water, growth of turf or paving.

† An unusual fall of rain sometimes causes a severe outburst of malaria. In October 1887 a very heavy rainfall occurred in the Ganjam district and was followed by such an outburst, the death-rate for that year in the town of Berhampur being 71·5.

especially when unaccompanied by sufficient drainage, and silting up of drainage channels, are also fertile causes of malaria.* In the North-West Provinces where "83 out of every 100 who died in 1886 are reported to have died from fever" (1,216,618 out of 1,467,613); the disease being most prevalent in the low damp wooded tracts of Rohilkhand and in the highly irrigated country about Meerut, the subjects of drainage in connection with irrigation works and the prevention of injurious waste of water are receiving attention from Government; and it can hardly be doubted that judicious expenditure on drainage works and prevention of over-irrigation would in such fever-stricken provinces be rewarded by a vast improvement of public health.

Mode of Infection.—Malaria is undoubtedly inhaled in the air which is breathed. It is generally believed that it may also be communicated by water.†

What is Malaria? It has long been believed that malaria is due to the growth of a microbe, because the conditions of its production are exactly those which are most favorable to fungous growth. The infection, being evidently an exhalation from soil or decaying organic matter, commu-

---

* The excellent report on fever in Cumbum by H. R. Farmer, C.S. (Procs. of Madras Govt., 1st April 1876) and that of the Sanitary Commissioner, H. King, are worthy of perusal in connection with this subject. Prior to 1865 Cumbum was a fairly healthy town. After that year fever death-rate increased enormously. For the first half of 1875, the death-rate reached 100 per 1,000! Depopulation was rapidly occurring. This extraordinary unhealthiness was due to "malaria arising from a swamp which, owing to the partial silting up of an important irrigation channel, has replaced for about two miles the running stream which originally drained efficiently the irrigated lands around the town."—*H. King.* This a type of similar occurrences elsewhere.

† See Parkes' *Hygiene*, pp. 61–64, for many instances of supposed infection by water. W. North (*Lectures on Malarial Fevers*, 1887) considers that malaria certainly cannot be communicated in this way. Dr. Colin of Paris adopted a similar view based on Algerian experience. The only direct experiments on this point with which I am acquainted were made by Dr. A. Celli, Professor of Hygiene in the University of Rome (*Acqua Potabile e Malaria*, Milano, 1886). He failed to communicate malaria to six individuals by water from notoriously malarious marshes. He also mentions that some parts of Rome which are most free from malaria are supplied with water (*acqua vergine*) derived from a malarious tract of country only a few miles from the city; whereas the most malarious parts are supplied with water carried in pipes from the healthy hills of Tivoli and Subiaco; and he gives several instances of places where malaria is very prevalent which possess a pure water-supply carried from a distance.

These facts, however, are of a negative nature, and though they show that malaria is not ordinarily conveyed by water, yet they do not disprove the possibility of its being so conveyed sometimes.

nicable through the air, and not contagious from person to person, the belief has also arisen that the poison, although it may be a product of external microbic growth, may be merely a chemical substance, and that malarial fever may possibly not be attended with the entrance of microbes and their growth within the body. Against this supposition it may be urged that the long continuance of malarial infection and frequent recurrence of characteristic fever, after departure of an affected individual from a malarious locality, is evidence that the poison remains and multiplies in the body, and that it is therefore probably due to a living organism which enters the body.* The remissions and intermissions which occur in the course of malarial fevers have also been cited as proofs of their being caused by microbic growth in the body, the growth occurring in successive crops; but it may be cited against this view that fevers due to non-microbic causes also present remissions, and that it is possible that "the paroxysmal febrile attacks are secondary phenomena resulting from injury to the nervous system, caused by the direct action of the poison."†

It is apparent, therefore, that, so far as general evidence goes, the microbic nature of malaria, however *probable* it may be, is not by any means positively established.

We have now to examine briefly what special and direct evidence exists to support the belief in its microbic nature. Outside of the body no micro-organism has yet been discovered which can indubitably be accepted as the cause of malaria.‡ Inside of the body, however, definite changes and bodies which may be micro-organisms have been discovered in the blood of persons suffering from malarial affections by Laveran (in Algeria) and Marchiafava (at Rome).§ During an attack of malarial fever transparent

---

* Some purely chemical poisons, however, are known to have a very persistent effect.

† G.M. Sternberg, M.D., Major and Surgeon, United States Army, *American Journal Medical Science*, 1885.

‡ In 1879 Klebs and Tommasi-Crudeli found a bacillus in the air of very malarious places near Rome, which they believed to be the specific organism of malaria, capable of infecting animals. Their observations have not been confirmed.

§ *Marchiafava and Celli.* Sulle alterazioni dei globuli rossi... e genesi della melanemia. *Atti R. Accad. dei Lincei*, 1884 (translated by author in Translations, South Indian Branch, B.M.A.). Also Nuove ricerche, *Arch. per le Scienze Mediche*, 1885 and 1887. *Laveran*, Traité des fièvres palustres, Paris, 1884. *Journal des connaissances Medicales*. Juillet, 1887, and

amœboid bodies which invade and destroy the red corpuscles of the blood are constantly to be found. They are sometimes furnished with flagelliform extensions, sometimes contain granules of pigment, and may become segmented. Their motions are arrested and they are destroyed by quinine. All attempts to cultivate them outside of the body have failed; but they do multiply in the blood * if injected by transfusion, which makes it probable, if it does not prove, that they are true organisms. In connection with their presence rapid destruction of the blood corpuscles, with formation of pigment, occurs. Malarial anæmia and pigmentation are thus accounted for.

Prevention of malaria.—Dryness and cultivation or paving of the ground and the avoidance of accumulations of decaying vegetable remains on its surface are generally the needful conditions for the prevention or mitigation of malaria.† Though it is too much perhaps to hope that malaria can ever be eradicated from India, there can be no doubt whatever that the mortality, suffering and inefficiency now caused by malarial fevers may be enormously reduced by well-directed efforts on the part of individuals as well as on the part of communities.

Deep drainage of damp town and village sites, so as to permanently reduce the level of sub-soil water in them, surface drainage and the clearing and improving of natural drainage channels, the management of irrigation so that

---

Lancet, pp. 993--1882, *W. Osler* of Pennsylvania, Hæmatozoa of Malaria, *British Medical Journal*, March 1887. The "plasmodia" have been described in India by Dr. Vandyke Carter at Bombay and Surgeon J. F. Evans, I.M.D. in Burmah, *British Medical Journal*, April 1888. For some years past microscopic examination of the blood has been used as a diagnostic test in doubtful cases of fever at the hospital of *S. Spirito* at Rome.

The author is much indebted to Prof. Marchiafava and Prof. Celli as well as to Dr. Tommasi-Crudeli for information and personal assistance in following their researches at Rome in 1883 and 1888.

* According to the experiments of Marchiafava and Celli. The nature of these organisms, if they be such, is still uncertain. *Woronin* discovered in 1878 that a certain disease of cabbage plants was due to a somewhat similar organism: *Plasmodiophora brassicæ*, which is "probably one of the simplest forms of *Myxomycetes*" (Koch). Lewis (*Quarterly Journal, Microsp. Science*, 1879) found flagellated organisms in the blood of rats. They have also been found in the blood of frogs, fishes and birds, and in the "surra" disease of mules and horses described by Evans in Burmah.

† The drainage of marshy lands in England (Lincoln) has rendered malarious places healthy. Malaria is almost unknown in parts of London in which it was formerly very prevalent, the improvement being apparently due to paving or building all over the surface. Rome is improving in the same way as building and paving extend.

stagnation may be avoided,* the filling up of hollows and foul tanks, surface draining and paving in towns and villages, removal of brushwood from and cultivation of waste lands, and planting grass and trees in certain localities, may be enumerated as measures within the province of communities.

Individuals should pay attention to the dryness of their dwellings. A damp-proof course in the lower part of the walls and impermeable flooring are important points in the construction of houses. Even mud-built huts may, with little additional labor, be rendered tolerably dry. They should be raised upon platforms of rough stones or gravel at least one foot above the level of the surrounding ground, the flooring being made of well-tamped clay or of cement. Slops and waste water should not be thrown upon the ground about a house, but should be used for watering plants in a garden some little distance away or else be conducted off by impermeable drains. The practice of plastering walls with cow-dung is to be condemned. In

---

* It is a remarkable fact that the irrigated and highly cultivated district of Tanjore is the least malarious in the whole of the Madras Presidency. Tinnevelly comes next and the dry bare district of Bellary third. The fever mortality for five years (1881–85) was as follows (per 1,000 per annum). Tanjore 2·0, Tinnevelly 3·8, Bellary 4·9, Trichinopoly 5·1, South Arcot 5·7, Salem 5·8, North Arcot 5·9, Nellore 5·9, Chingleput 6·6, Coimbatore 6·7, South Canara 7·2, Godávari 8·2, Kistna 8·2, Malabar 9·0, Madras 9·3, Ganjam 10·9, Vizagapatam 11·7, Cuddapah 11·7, and Kurnool 15·2. In 1887 it reached 23·7 in Kurnool and was only 1·3 in Tanjore. Kurnool has a good deal of canal and tank irrigation; but the natural drainage is bad, there is no artificial drainage, and the soil is retentive of moisture. Tanjore is more richly irrigated; but the sub-soil is porous and there is excellent natural drainage.

The contrast of these two districts shows that irrigation in itself is not by any means necessarily productive of malaria, and that the remedy suggested (in Parke's Hygiene) of preventing irrigation for some distance around towns and villages (even if such a measure were practicable without great reduction of food-supply and revenue), is of small value compared with drainage. The excessive use of irrigation water might be checked with great advantage as to dryness of soil, probably also as to its productiveness and as to allowing a larger area to be brought under cultivation. Intermittent irrigation with smaller quantities of water would allow proper aëration of the ground. Great waste of water and water-logging of soil, resulting in detriment to health and to crops, is probably often due to cultivators taking too much water on the principle of obtaining full value for their money, as men already satiated *will* drink a pot of liquor to the dregs.

Though I know of no exact statistics on the subject, it is a matter of general observation and belief that lands under well irrigation, and consequently receiving a minimum of water, are not only more healthy, but bear better crops than over-irrigated lands under tanks and canals.

malarious districts, windows and doors should not be placed to face winds which are known to excite fever, persons should avoid evening mists and sleep within doors upon charpais or bamboo cots, such as are already used in some malarious places. The water of surface wells or tanks should not be drunk, and it is advisable to boil all drinking water.

Cholera.

While malaria most affects thinly populated rural districts, cholera is most fatal in towns and densely populated places.* The reason of this is not far to seek: the conditions of a large population tend to check the production of malaria; while cholera, being essentially a communicable "filth disease," is directly encouraged by density of population in the absence of good sanitary conditions. It has a close resemblance to enteric fever in this and other respects.

The Mortality from cholera is much less than from fever, the registered mortality in the Madras Presidency for five years 1881–85 being 1·4 per 1,000 of population per annum against 7·2 from fever; for the same period in Bengal the cholera death-rate in towns was 4·08 and in districts 1·91. But as most of those attacked who do not die recover without permanent ill-effects, and about 50 per cent. of those attacked do perish, it is evident that cholera does comparatively little damage except by the mortality which it causes. This mortality, however, is very great, it should be *entirely* prevented, and its occurrence is evidence of bad sanitary conditions which endanger life and deteriorate health in other ways also.

Favoring Conditions which encourage the prevalence or extension of cholera are a high temperature, moisture of ground, stagnation of air, and bad sanitation, especially a contaminable water-supply. It is checked or arrested by cold or by drought and by sanitary measures. The seasonal prevalence of cholera is well-marked, especially in places where the temperature and dryness are most variable

---

* "The death-rate was by far greatest in towns, the mortality in them having been in the ratio of 3·3 per mille against 1·9 in rural districts."—*Madras Sanitary Report*, 1885. The same fact is observed everywhere, the difference being often much greater than this. A part of the difference is no doubt due to defective registration. For the five years 1881–85 the cholera death-rate in Madras municipal towns was 2·6.

with season. Even in South India this character is strongly marked. Taking the Madras Presidency as a whole, we find from the returns of a series of years that cholera is far more prevalent in December, January and February, than during the rest of the year; the mortality during those months being nearly twice as great as during all the rest of the year.*

The "endemic home of cholera" is Lower Bengal; but it has established itself as an endemic in a few other localities, such as the Madras district of Tanjore which has not been free from it for many years. In those regions the conditions which favor it are always present. It spreads at intervals in epidemic waves from Lower Bengal. "History repeats itself" constantly in cholera epidemics, the disease following the same roads at the same seasons and visiting the same localities.† Cholera epidemics in the Madras Presidency recur at intervals of six or seven years, there being a period of repose of one or two years, followed by an outbreak which increases till it reaches its greatest severity about the third year and then rapidly declines during the following year or two.

The Nature of Cholera cannot be regarded as known beyond doubt, though the balance of evidence is much in favor of the view that the disease is caused by the microbe ("comma-bacillus") discovered by Koch in Egypt in 1883. The circumstances of the epidemic development, spread and arrest of the disease point almost conclusively to its microbic origin; there is strong evidence that the infection is contained in the bowel discharges of the sick; and the

---

* Cholera is endemic in the Tanjore and Ganjam districts, and it is rarely absent from South Arcot. In the north districts on the Coromandel Coast, it is most prevalent from June to September, least in the cold weather. In Madura, Tinnevelly, Coimbatore and Salem, the only great rise is in the cold weather, though in Salem it does not abate much before June. In the other districts there are two periods of high mortality, the first and most marked in the cold weather (December-February) and the second during the south-west monsoon (June-September).

† "So long as the insanitary conditions remain, epidemics invariably haunt the same localities, and the first appearance of the cholera in Bermondsey in 1848 was close to the same ditch in which the earliest fatal cases occurred in 1832. The first case of cholera that occurred in the town of Leith took place in the same house and within a few feet of the very spot from whence the previous epidemic of 1832 commenced its course. On its reappearance in 1848 in the town of Pollockshaws, it snatched its first victim from the same room and the very bed in which it broke out in 1832." Sir D. Galton, *Society of Arts*, 1886.

microbe (Koch's) is always found growing abundantly in the inflamed intestine in cholera, but not in other diseases. The microbe can be easily cultivated outside of the body on moist organic matter, or in nutrient liquids; but it is somewhat doubtful if the true disease has been communicated to lower animals, though Koch claims to have communicated it.

There is no reason to assume that cholera is anything more than a local inflammation of the intestines. Its clinical and anatomical characters warrant no other conclusion; and acute inflammation of the intestines from other causes produces very similar symptoms.

The microbe of cholera is really a short *spirillum* and not a *bacillus*, as Koch at first supposed. Like other spirilla it has no "resting stage" and never forms spores, but is easily killed by drying * and grows only in fluid or in very moist substances. It grows readily on moist earth and on the moist soiled clothes of cholera patients, and it was found by Koch in the water of a Calcutta tank where such clothes had been washed and which was drunk by persons among whom the disease was epidemic. It multiplies with great rapidity, then remaining stationary for a short time and rapidly diminishing. These microbes flourish best at a temperature between 30° and 40° C. (86° to 104° F.) and cease to grow below 16° C (60° 8 F). They may be frozen without dying. They cease to grow in the absence of air, but when it is restored they grow again.†

Mode of Infection.—The conveyance of cholera by men from place to place is a certain fact. It is also certain that the disease may be produced by drinking water which has been defiled by cholera excreta, and there is an immense amount of evidence that this is the usual manner of its dissemination. There is also some evidence to show that it may be communicated by infected food, by soiled clothes, &c., and by emanations from the bowel discharges of persons affected with the disease. Its conveyance by human intercourse is shown by the broad facts that it travels along the lines of communication, spreads from a centre in a

* Dried on glass plates they die in two or three hours.

† Koch, Cholera Conference, Berlin, 1884. The proved specificity of Koch's cholera spirillum is denied by Klein and others, but is accepted, sometimes with reserve, by many pathologists. Dr. E. Klein's recent work *The Microbes in Asiatic Cholera*, Lond., 1889, is one of the most valuable contributions on the subject.

populous place, and enters countries beyond the sea by those sea-ports which are in communication with places where the disease prevails. It constantly breaks out among the crowds who congregate at fairs and pilgrimages and is frequently carried through the country by infected parties of them as they travel to their homes.*

As to the communicability of cholera by water soiled with cholera excreta, the first well-investigated cases were recorded by Dr. Snow in 1849 and in 1854 in England, and since then very numerous instances have placed the matter practically beyond doubt.† In 1886 cholera was largely prevalent in Calcutta, and it was found that most of the cases took place in those localities where the public water-supply was most deficient and that a large grouping took place round tanks.‡

Its conveyance by food is probably less frequent. A case is related § where an epidemic occurred among persons who partook of rice which had been spread on a mat in a hut where a man had died from cholera.

Cases of conveyance by infected articles have not often been traced with certainty. In 1864 cholera existed in the camp of the 74th Highlanders at Guindy near Madras.

---

* Its propagation by persons returning from Hurdwar fair is the most often cited instance and Dr. J. M. Conningham himself stated "that the cholera went with the pilgrims in every direction is a fact which admits of no dispute." Pilgrims from the Tripatty festival are well-known to be frequent carriers of cholera to Madras and other places. A severe outbreak in the town of Cuddapah during the famine of 1877 was witnessed by the author, and could be traced to no other origin than the use of an important well by a gang of laborers among whom the disease had broken out and who were encamped outside of the town. In 1887 "in Midnapore cholera was imported by the pilgrims returning from Puri."

† Numerous English instances will be found in the reports of Dr. Farr and Mr. (now Sir J.) Simon. The case at Theydon-Bois investigated by Mr. N. Radcliffe in 1865 is a good example. Parkes and G. Wilson give many cases and references. In 1885 cholera caused great mortality in Spain and it was observed in instances too numerous to be mere coincidences that towns or parts of towns supplied with pure water were little or not at all affected. *British Medical Journal*, 9th October 1886. In Italy, Rome which is well supplied with water has never been severely attacked by cholera, while other towns with bad supplies have suffered heavily.

‡ See Reports of Health Officer, Dr. Simpson. The greater mortality in the suburbs than in the city of Calcutta may be explained by the polluted tanks which afford much of the water-supply of the former. In 1886 the total mortality from all causes in Calcutta city was 26·42 and in the suburbs 40·51.

§ *Hygiene of Cholera*, by Surgeon-General C. A. Gordon. The original report is not referred to.

Two cartmen who were engaged in transporting the tents of the regiment appropriated some *straw* which had been spread in the tents of cholera patients. On their way home to Chingleput (more than 20 miles distant), they were attacked with cholera and died the day after their arrival. The disease then spread in the town which had been free from cholera for years.* If infected articles may convey the disease, it must be possible for healthy persons to convey it on their clothes or bodies.

The following is apparently an instance † of infection by emanations from excreta. It occurred in 1882 at Jabalpur which was then free from cholera. A sepoy was taken to hospital, ill with cholera, and soon afterwards another, both from a guard at the central jail. On inquiry it turned out that there was no latrine provided for the jail guard, and the men resorted to the latrine belonging to a *serai* at which railway travellers were wont to put up. A traveller ill with cholera had been taken out of the train on the previous day and been carried to the *serai* when he had made free use of the latrine.

The poison of cholera appears to be rarely if ever carried by air to any distance, for it is certainly not spread by wind. The microbe appears to be readily destroyed by drying.

Prevention of Cholera.—General sanitary measures conducive to purity of earth, air, dwellings, food and water are most effective.‡ Purity of water is particularly important. Cholera has been comparatively inoperative in Madras since the Red Hills water-supply was opened.§ Isolation of the sick, and especially disinfection of their discharges and soiled clothes are important when the disease has occurred.

---

* Madras Sanitary Commission, 1866.

† Communicated by my friend Surgeon-Major W. J. Busteed, M.D.

‡ W. R. Cornish (Report of the Sanitary Commissioner, Madras, for 1870) gives many instances of the immunity of clean jails with good water.

§ "Even the deaths which have occurred in Madras are found to have mostly taken place in outlying parts of the town, where the Red Hills water has not yet been laid on, except in one district, Triplicane. Here live a large number of Mussulmans, and their women, being gosha, are obliged to draw their water from small wells in their backyards, always perilously near the cess-pits . . . . During 1881-84 the Madras Presidency was visited with one of the severest epidemics of cholera on record, and yet it will be seen that the mortality in Madras city itself was comparatively slight. Two or three times it re-appeared in the town coincidentally with the return of pilgrims from some religious gatherings, but it died out." Deputy Surgeon-General M. C. Furnell—*Lancet*, 18th October 1886.

Quarantine is ineffective and harmful for reasons already given.*

At fairs, festivals and other large temporary gatherings, the local authority should make due provision in advance for an uncontaminable supply of water, for sufficient latrine accommodation, and for separation of the sick in case of cholera or other epidemic disease occurring.

Small-pox.

Small-pox is a no less preventible disease than cholera, and it is more loathsome and the cause of more suffering, although neither its absolute nor its relative mortality is so great. The former for 1881–85 in Madras Municipal towns was 2·2 per 1,000 of population, and more than 20 per cent. of persons attacked die. It is essentially an epidemic disease, though it must be regarded as endemic nearly every where in India, and severe epidemics of it recur generally at intervals of about five years. The last epidemic culminated in 1884, and in that year there were 333,000 deaths from small-pox in India (61,247 representing a death-rate of 2·1 per 1,000 of population in Madras). In London, in 1771–80, small-pox caused 10 per cent. of the total deaths, in 1831–35, 2·7 per cent., and in 1861–70, only 1·1 per cent. (0·2 per 1,000 of population). It may thus be seen that before the introduction of vaccination small-pox was more fatal in London than it is now in India, while at the present day it is very much less so.

The *contagion* of small-pox is very persistent, and it may act through a considerable distance.†

---

* *Vide* Dr. Thorne on Cholera Quarantine in Report of Medical Officer, L.G. Board for 1885, and Dr. Buchanan, 1886.

The International Sanitary Conference of Rome in 1885 recommended for sea quarantine from the Red Sea—

(*a*) *Suspected vessels.*—Medical inspection near Suez. If the officer making it is satisfied that there is an absence of all suspicion, free pratique to be immediately granted.

(*b*) *Infected vessels.*—Five days' quarantine.

Turkey imposes a quarantine of five days in all cases of pilgrim ships from Arabia, ten days if they have sailed from ports where cholera prevailed, even if they have no cases on board, and fifteen days *minimum* if there has been cholera, and fifteen days after the last case of cholera at the lazaretto. *Conseil de Santé.* Constantinople, 1886.

The nations which practice quarantine suffer most from cholera!

† *Probably* for at least a mile through the air. *Vide* Mr. Power's observations in Dr. Buchanan's Report to L.G. Board, 1885. The risk naturally diminishes rapidly as the distance increases. "Houses within a radius of

It is commonly propagated through the air in the vicinity of the sick and by infected articles, such as clothes which may, for instance, give the disease to a washerman's family and thence convey it to his customers, or such as carriages in which a diseased person has ridden, or such as the clothes and bodies of persons who have been in contact with the sick, as well as by direct contact. The importance of isolation and disinfection in this disease is therefore great.

One attack of small-pox protects against a second attack generally for life, though the protection becomes weaker as the time increases after the attack.*

Nature of Small-pox.—Small-pox is a typical acute microbic disease. It is peculiar to man, though several other animals suffer from closely similar diseases. So far as is known, the microbe—a minute *coccus*—grows only in the body.

Prevention of Small-pox.—Under this head we shall consider (1) isolation and disinfection, (2) inoculation and (3) vaccination.

Isolation and Disinfection are undoubtedly efficacious, but it is difficult to carry them out thoroughly. Small-pox hospitals should be as far as possible from dwellings, and every precaution must be taken to prevent the spread of infection by attendants and servants, as well as by other means. In London such hospitals were found to be in some way centres of infection.

Inoculation, first practiced in eastern countries, was introduced into England from Turkey in the first half of last century. It is even now unfortunately practiced by a few ignorant persons in India. It did not cause any diminution of the general mortality from small-pox. The inoculated disease was milder and much less fatal than that otherwise acquired, and it produced immunity from a second attack; but it propagated and diffused the contagion of the disease and rendered it more difficult to stamp out, while it added greatly to the danger of the many who did not submit to

---

half a mile have been attacked at three times the rate of those between half a mile and a mile of it (small-pox hospital), and at nearly four times the rate of the parts beyond."

* Dr. Crombie (Dacca, 1885) noticed the occurrence of small-pox in prisoners who bore marks of inoculation, and he found that 38 per cent. of such prisoners were susceptible of vaccination.

the operation. Inoculation of small-pox is then strongly to be condemned, mainly because it propagates and supports the disease which we want to suppress.

Vaccination.—Dr. E. Jenner, in the year 1798, first published an account of his great discovery. For many years previously he had been making observations, but he had great difficulty in obtaining acceptance for his views. When put to the test of experiment, however, they speedily triumphed; and in a few years vaccination became very general among all civilized nations.

There was a popular belief in some parts of England that persons who had suffered from "cow-pox"—sores which sometimes appeared on the hands of milkers who milked cows suffering from a certain eruption on their teats—could not get small-pox. Jenner investigated this belief and concluded that it was founded on fact. At length he inoculated a boy with the cow-disease and found that he was then proof against small-pox inoculation. He also discovered that the cow-pox could be transmitted from person to person by inoculation.

It is still however more than doubtful that human small-pox and cow-pox are one and the same disease. They are certainly similar * and probably own a common origin, or one may have been derived from the other; but it is certain, so far as we know, that their present characters are very permanent and distinct. *Vaccinia* has been passed through man for thousands of generations (of the disease) without reverting to small-pox. On the other hand, attempts to inoculate cows with small-pox have failed.† In appearance the microbes of vaccinia and variola are similar, except that they differ in size.

The advantages of vaccination over small-pox inoculation are that it affords similar protection not only with comparative safety, but practically with absolute safety, that it does not propagate a dangerous nor very easily communicable disease, and that it ought to enable us eventually to extinguish small-pox altogether.

* *Inoculated* small-pox runs a very similar course to vaccination.

† *E.g.*, Klein's experiments in 1879, with the co-operation of Ceely, who had claimed, in previous experiments, to have obtained vaccinia by inoculating cows with variola.

"The protection which vaccination affords against small-pox is manifested in two ways; firstly, by the immunity from that disease which, as a rule, it confers; secondly, by the modification which, when immunity is not complete, it induces in the course and severity of the disease." *

The degree of protection afforded by vaccination depends mainly upon (1) the time which has elapsed since its performance, and (2) the mode of its performance—the protection given by vaccination in three or four places being much more perfect than that conferred by vaccination in only one spot. The comparative and absolute immunity from the disease, and the greatly lessened mortality when attacked, as well as the value of vaccination at several points, are shown by abundant statistics. The following examples will be sufficient:—

In 1880-81 in London the deaths from small-pox were 3·35 per 1,000 among the unvaccinated and only 0·09 among the vaccinated—the difference in young people, especially in infants, being much greater.†

At Sheffield during a late epidemic there were 95,000 vaccinated and 5,000 unvaccinated children under 10 years old. Among the former there were only 189 cases and 2 deaths, while among the latter there were 172 cases and 70 deaths. Among adults in hospital there were 32 deaths, 21 being of unvaccinated persons and 11 of persons once vaccinated on an average 30 years previously.‡ At Fulham Small-pox Hospital since its opening 295 persons were engaged on the staff. Of these 8 took small-pox—none of them being nurses. Four of the 8 had not been re-vaccinated, 2 had been unsuccessfully re-vaccinated, 2 had been re-vaccinated too late to prevent the development of small-pox.§ At London Small-pox Hospitals the disease was "modified" in only 2·6 per cent. of the unvaccinated and in 78 per cent. of the vaccinated. The death-rate in the former class was 35·5 per cent. and in the latter 6·5. But in nearly all fatal vaccinated cases vaccination was found to have been imperfect.||

---

* Dr. E. C. Seaton.
† Buchanan's *Memoir on Small-pox*, 1881.
‡ Report of Dr. S. White.
§ *British Medical Journal*, 21st August 1886.
|| E. C. Seaton.

The following are Dr. Marson's well-known statistics (5,000 cases *) :—

(1) Unvaccinated mortality per cent.	...	35
(2) Stated to have been vaccinated, but having no cicatrix	...	23·57
(3) Vaccinated—		
(a) Having one vaccine cicatrix	...	7·73
(b) " two " cicatrices	...	4·70
(c) " three " "	...	1·95
(d) " four or more "	...	0·55

The operation of vaccination consists in the insertion of vaccine lymph (taken from a vesicle on the eighth day and applied direct or after preservation in glass tubes or between glass plates) into punctures made in the skin, or rubbing the lymph into abrasions made by scraping the skin with a lancet point or with an instrument made of three or four needles tied together. At the end of the second day a small reddish elevation (papule) is perceptible. By the end of the fifth day this has become a whitish blister (vesicle) with a central depression. On the eighth day it is pearly and distended with clear tenaceous fluid (lymph), the central depression being well marked and the vesicle surrounded by a circle of inflammation. This continues to enlarge and swell for two days longer, when it begins to subside and the vesicle to dry. About the fourteenth day only a dry brown scab remains, which falls off about a week later. The scar (cicatrix) which is left is depressed and marked with little pits (foveated).

Vaccination instruments are best purified by being inserted for a second or two into the flame of a spirit or other lamp before each vaccination.

Re-vaccination is important because the protective effect of primary vaccination, especially if it has been imperfect and only performed at one or two spots, gradually becomes less. Young people should be re-vaccinated on reaching the age of puberty; and, whenever a case of small-pox occurs in a house, all residents in it should be immediately vaccinated. If a person be vaccinated within two days after exposure to small-pox contagion, small-pox is entirely

* Records of nearly 12,000 cases treated in the hospitals of the Metropolitan Asylums Board show very similar results.

prevented, and if on the third day it is "modified" and rendered less severe.*

Vaccination, even in the youngest infants, is practically without danger if properly performed. The lymph should be taken at the proper time from a healthy subject and the person to be vaccinated ought not be sick at the time. Erysipelas *may* attack the vaccinated spot, as it may attack a boil or a scratch if the subject be exposed to infection. Syphilis has been communicated by careless operators, but it has been shown that lymph obtained from an infant with congenital syphilis does not communicate the disease if the infant's skin be free from eruption at the time.†

Calf vaccination has, however, been introduced to guard against the introduction of human disease by careless vaccinators. The original cow disease is more severe than humanized vaccinia; no attempt is therefore made to reproduce it, but the shaven belly of a calf is inoculated with humanized lymph. The cycle of the disease is shortened, the vesicles maturing in four or five days and producing little or no secondary inflammation or constitutional disturbance in the animal. A calf is able to support a hundred vesicles without inconvenience.

Vaccination, in the countries where it is general, has had a remarkable effect upon the statistics of small-pox. We have seen that it has caused an enormous reduction of small-pox mortality; but it has also shifted the mortality of that disease from infancy to mature age. In England, 40 years ago, the deaths from small-pox under five years of age were three times as numerous as those above that age; these proportions have gradually changed as vaccination became more general, until at the present day they are reversed, the deaths above five years being three times as numerous as those under. Most of the deaths now are above the age of 20. The evident explanation of this fact is that the influence of primary vaccination gradually diminishes; and the deaths from small-pox are now mainly confined to non-vaccinated persons and to persons who have been (often imperfectly)

* Vaccination is protective when the areola is developed (ninth day) and the incubation time of small-pox is twelve days. *Vide* Marson (Reynold's Med.)

† In L. G. B. (England) Report for 1886 in 800,000 cases of vaccination cited, not one case of syphilitic transmission was known.

vaccinated in their infancy and have never been re-vaccinated. These statistics afford a strong argument in favor of re-vaccination.

We may also conclude from them that where the infantile mortality from small-pox is greater than the adult mortality from that disease, there is almost certainly defective vaccination. In 1884, in Bengal 72 per cent. and in Madras 64 per cent. of the deaths were of children under 12 years of age. In Madras city, during the epidemic of 1883–85, no less than 97 per cent. of the total deaths were in infants and children. This proves that infantile vaccination was much neglected, and that the adult population was largely protected by previous attacks of small-pox or by vaccination. After this epidemic, when vaccination was rendered compulsory in 1885, small-pox almost disappeared from Madras; but this disappearance was no doubt partly due to the protective effect of the preceding epidemic (and possibly to some concealment of cases).*

Dysentery.

The mortality from bowel diseases is great in most tropical countries, where malaria is rife, and even in malarious parts of temperate countries. In the municipal towns of the Madras Presidency,† during 1881–85 the mortality from these diseases was 3·5 per 1,000 of population, and in 1887 it was 4·1, and a large part of this mortality was certainly due to dysentery. Impure water and bad food are undoubtedly common causes of dysentery and diarrhœa. The general coincidence of malaria and dysentery suggests that they own a common cause, or else are related to each other as cause and effect, but the exact nature of their connection, if any, is still uncertain. Malaria, impure water, and unwholesome food being known as the commonest *primâ facie* causes of dysentery, the best means for reducing the mortality from this painful and very fatal disease are sufficiently evident.

---

* In a well-vaccinated community, the vaccination-rate ought not to be much lower than the birth-rate. The Madras Presidency birth-rate is about 42 per 1,000 and the vaccination-rate 23.

† For the five years 1883–87 in Madras districts, the registered mortality was only 0·96. It is doubtful how far this small proportion is due to faulty registration. In Bengal, 1881–85, the urban mortality from bowel-complaints was 3·79, and the rural 0·78.

Tuberculosis

exists all over the world and accounts for the deaths of nearly one-seventh of mankind. It is a common disease in Madras and many other parts of India. Pulmonary tuberculosis (consumption) is its most frequent form. Cattle and many other animals suffer from this disease, and it is communicable from them to man. Its intimate cause is a minute *bacillus*.* It appears to be commonly communicated through the air, but it may be communicated by food, such as milk or uncooked flesh of diseased animals, and by inoculation. The *virus* of tubercle is not easily destroyed; it retains its vitality, probably in the form of spores, in water, in putrefying matter, and when dried.† The tendency to phthisis is certainly hereditary, and it is stated to be hereditary by different authorities in from 30 to 80 per cent. of the cases.

Phthisis is also much encouraged by dampness of soil, ‡ overcrowding, deficient exercise, bronchitis, and bodily debility from any cause.

The best measures for its prevention are evident from the foregoing remarks; they may be divided into (1) prevention of the tendency to phthisis by increasing vital resistance through good personal hygiene and residence in a dry climate (of high altitude when possible), and (2) prevention of infection by disinfecting discharges from the lungs or other diseased parts in tubercular persons and avoiding rooms inhabited by them, and by destroying, or at all events not consuming without very thorough and prolonged cooking, the meat or milk of diseased animals.

Syphilis

resembles tuberculosis in its slow progress and its lengthened duration. It is assumed to be of microbic nature

---

* Described and investigated by Koch.

† Galtier *Union Medicale*, Aôut., 1887. Koch had previously arrived at similar conclusions. It is incompatible with our limits of space to give examples and authorities regarding the communication of tuberculosis in various ways. They will be found abundantly in the medical periodicals for the past few years. Koch (1884) concluded that the most usual causes of infection in man were the dried matter coughed up by phthisical patients, and meat and milk. Its frequent communicability by meat and milk was strongly urged at the Paris Conference on Tubercle (1888), and the disease has been included in the French Contagious Diseases of Animals Act.

‡ A fact established by Buchanan's well-known investigations.

from its clinical history and natural characters, though its specific microbe is not yet known.* So far as is known it is communicable only by inoculation. Inoculation may take place accidentally in various ways; for instance, surgeons are not rarely inoculated through scratches on their fingers; babies have infected nurses, and razors have also communicated the disease †; but it is habitually communicated by sexual intercourse. It is mainly spread by uncleanly prostitutes.

Though syphilis is not often directly fatal, it often causes much suffering and prolonged ill-health and degenerations of organs which may conduce to death from other causes. It is also transmitted frequently to the offspring of syphilitic parents (congenital syphilis). The disease is common all over India, very prevalent in some places; but accurate statistics of it are wanting. In 1885, 4,000 cases of syphilis (in 14,000 of "venereal diseases") were treated in Calcutta hospitals.

Prevention of Syphilis.—This disease, as well as gonorrhœa and local contagious sores, could be greatly mitigated, if not completely stamped out, by organized inspection and the isolation and treatment of diseased prostitutes. Those of the lowest class require most attention, since they are the most active agents in its propagation. Such inspection and treatment was carried out for many years at large Military stations in England and in India with great benefit to the troops, to the civil population, and to the prostitutes themselves; but in 1883 some misguided, but very clamorous, persons in England raised an outcry against the *Contagious Diseases Act* which has resulted in its—let it be hoped only temporary—abrogation. Syphilis has been increasing in the army since that time.‡ Prostitution cannot be suppressed by the State so long as sexual passion and present social conditions remain. It is regulated by law in many European states with obvious benefit. So far

* Mr. Jonathan Hutchinson, one of the highest authorities on the subject of syphilis, says "I have always .... held firmly to the belief that it is due to .... a living microbe." Medical Soc. of London, 20th February 1888.

† *Lancet*, 20th November 1886.

‡ For evidence see Parkes' *Hygiene*, 7th Edition, pp. 473–78. Lord C. Beresford stated in the House of Commons (September 1886) that "the large increase in the sick list in the navy was due to the abrogation of the Contagious Diseases Acts and to the campaign recently undertaken."

from promiscuous immorality being encouraged thereby, the reverse is the case; for many young girls who wish to change their mode of life are enabled to do so, and it is probable that domestic morality is increased.

Leprosy.

This disease, like syphilis, is probably communicable only by inoculation. Its very chronic nature and insidious development render it in most cases impossible to trace the manner of infection. Until recently it was considered by most pathologists to be non-infectious; but since the discovery of its microbe—"*bacillus lepræ*"—in the affected tissues,* belief in its infectious nature has been steadily growing, until lately this belief has been extended and confirmed by the strongest evidence.†

This disease is very prevalent and probably increasing in some parts of India.‡

Prevention of Leprosy.—Segregation of the affected is the only means, and it is proving an effectual though slow means in Norway. Three practicable methods of isolation are mentioned by Dr. H. V. Carter:§ (1) asylums for detention and supervision; (2) leper colonies or villages, the inhabitants to be supervised to prevent their mingling with the neighbours: waste places might be reclaimed and colonized; (3) isolation of the affected in their homes.

It is most important that the communicable nature of the disease should be made generally known. Marriages of lepers should be discouraged.

---

* By Hansen in 1874 and investigated by Neisser in 1880.

† Several cases of communication were cited in the medical periodicals during 1888 and the disease has been communicated by experimental inoculation of a convict at Honolulu by Dr. Arning—vide *British Medical Journal*, 24th November 1888.

‡ According to the last census 14 per 10,000 of population in Berar were afflicted with this disease, being more than twice as many as in any other part of India.

§ Bombay G.O.G., No. 756, 5th March 1884. The subject of segregation is now being considered by the Government of India. *Proc., Home Department*, 15th June 1889.

CHAPTER XI.

VITAL STATISTICS.

Preliminary Considerations.

"Statistics are the numerical expression of collected facts and their relations."* *Vital statistics* may be defined as the statistical method † applied to the investigation of facts relating to human life.

Statistics are necessary for ascertaining and expressing with precision aggregate facts which are so large numerically as to be otherwise evident in only a vague and general manner, or to completely elude ordinary observation, for determining the relations of such facts to each other; and for making inductions as to the causes and laws of such facts.

The *units* composing the *aggregate numbers* ("primary statistical quantities"), which form the bases of all statistics, must necessarily be properly collected and grouped together. One of the commonest sources of untrustworthiness in statistics is the incorrect enumeration or grouping of units. It is desirable that all statistics should be accompanied with descriptive statements explaining the method by which the units have been collected and grouped together, so that any possible or probable inaccuracies may be taken into account.

---

* H. King: *Madras Manual of Hygiene.* This is the clearest and best definition I know. A yet briefer, but more limited, one which may be suggested for vital statistics is *sociology investigated mathematically.* This is but an abbreviated paraphrase of M. Block's well known definition: "la science de l'homme vivant en société en tant qu'elle pent être exprimée par les chiffres." *Traité de Statistique,* 1878.

† *The statistical method* "is a scientific procedure (1) whereby certain phenomena of aggregation not perceptible to the senses are rendered perceptible to the intellect, and (2) furnishing rules for the correct performance of the quantitative observation of these phenomena." Art. "Statistics" in *Encyclop. Brit.*

Primary numbers, or simple statistical quantities, must contain all the units of a like kind, which are to be enumerated. The errors which are likely to exist in such numbers are due to (1) omission of correct units, or (2) inclusion of incorrect units. For instance, in a return of deaths from cholera in a population (1) some cholera deaths may be omitted owing to improper statement of cause or concealment of death, or (2) some deaths from dysentery and diarrhœa or other diseases may be included; the result being, in either case, an incorrect *primary number* expressing the deaths from cholera. Clear definition of the distinctive characters of the group to be represented, and accurate collection of all units belonging to that group, and of no others, are necessary in order to obtain a correct *primary number*.

Statistical facts may be expressed either (1) by simple statement of one or more primary numbers, (2) by the *ratio* of two or more numbers, or (3) by *averages* (*means*) deduced from two or more numbers.

Ratios,

or proportions, are useful in showing the relative numerical importance or size of two primary numbers which are to be compared together, and in reducing them to a uniform scale, so that they may be compared with other proportional numbers. For example, if the mortality in three towns was as follows:—

Towns.	Population.	Deaths.
(1)	4,680	117
(2)	33,700	1,078
(3)	18,375	496

the actual numbers do not convey a clear idea of the relation of deaths to population in any one of the towns or of the relative mortality of the three towns. But if we state that out of every 1,000 persons in each town the following number died:—

(1)	25
(2)	32
(3)	27

the ratios are at once evident.

The most usual, and generally the best, method for comparing two numbers is to state one (usually the larger) as 100, and the other as a *percentage* of this.

Another method of stating a ratio, which is sometimes useful (for it appears to convey a more definite and vivid impression to minds which are unused to deal with figures), is to reduce the smaller number to unity and state it as "one in so many." For instance the mortality of the three towns in the above example may be stated as 1 in 40, 1 in 31, and 1 in 37, respectively. This method possesses the disadvantage that the changing number becomes greater or less *inversely* as the facts it represents increase or diminish in number. A percentage increases or diminishes *directly*.

When several proportional figures have to be compared together, the percentage method is especially preferable. If the two numbers differ greatly in magnitude, it is convenient, in order to avoid fractions, to state the larger one as 1,000 or some multiple of 1,000,* the smaller one being proportionately increased.

Fallacies of Ratios.—The value of a ratio as an average statement of fact, or as an indication of future probability, depends mainly upon the number of units upon which it is based: the larger the number, the more trustworthy is the ratio. For instance, if in a household of ten persons two deaths happened in one year, the mortality of that particular household was at the rate of 200 per 1,000, or 1 in 5 per annum; but it would be manifestly absurd to accept this as representing the mortality of the town in which the household was situate, or as an indication of the probable future mortality in similar households. But if we have 3,000 deaths in a population of 100,000 persons, the death-rate of 30 per 1,000 may be accepted as closely representing the true death-rate of a population of which the 100,000 is a fair sample and as an indication of what their future death-rate will be under similar circumstances. In stating a ratio, therefore, it is always important that the

---

* The calculation of a percentage is an operation in "simple proportion." For example in the first of the towns mentioned above 117 has to be calculated as percentage on 4,680 and $\frac{117 \times 100}{4{,}680} = 2{\cdot}5$ which is the required percentage. *To reduce the smaller number to unity* and the larger number proportionately, divide both by the smaller number. In the same example $\frac{117}{117} = 1$ and $\frac{4{,}680}{117} = 40$.

numbers upon which the ratio is calculated should be made known.* In most cases conclusions derived from less than 100 units must be regarded as unreliable and only to be accepted provisionally, subject to confirmation. Those founded on 1,000 units are generally very close to the truth; and 10,000 units may be regarded as affording practical accuracy for most purposes.†

Ratios should not be founded upon two variable factors: one of the factors must be fixed and the other variable. It is a common error, for instance, to calculate infantile deaths as a percentage of total deaths, the correct method being to calculate them on the infantile population; and, similarly, deaths from one disease should not be stated as a proportion to deaths from all diseases. Methods of this kind should, at all events, not be resorted to except for special purposes, and keeping in view the errors they involve. In the case of variable populations corrections can be made for differences of increase, diminution, or age-constitution, so that their rates may be strictly comparable. In Indian statistics all ratios reckoned on population are more or less incorrect, because they are calculated on the *uncorrected* populations of the previous census.

Means.

The *mean* or *average* of a series of numbers indicating similar facts is a single number which is representative of the series or group.‡

A mean not only represents a group of numbers by a single number, but it may afford a more or less trust-

---

* Various empirical rules have been devised for testing the value of ratios. The best known is *Poisson's formula:* let $\mu =$ total number of facts, $m =$ number in one group, $n =$ number in the other group; the extent of variation in succeeding instances will be $\frac{m}{\mu} + \sqrt[2]{\frac{2\,m\,n}{\mu\,3}}$ and $\frac{n}{\mu} - \sqrt[2]{\frac{2m\,n.}{\mu\,3}}$

† The degree of accuracy increases not directly, but as the square root of the number of observations.

‡ The *arithmetic mean* is the true mean for ordinary statistical inquiries. It is obtained by dividing the sum of the series by the number of members in the series. For example, the mean of 56, 32, and 41 is $\frac{56 + 32 + 41}{3} = 43$. In certain cases, however, the arithmetic mean is not correct; thus, when the members of a series differ in "weight" (relative importance), the true or *geometric* mean must be obtained otherwise.

worthy indication of future probabilities with regard to facts of the same nature. Generally speaking, the larger the number of members upon which the mean is calculated and the less they individually diverge from the mean, the more valuable is that mean, whether as a representative statement of the facts indicated by those members, or as a forecast of probabilities.

To judge of the value of a mean the *extremes*, that is the lowest and highest item represented by the mean, should always be stated. The extent of divergence, + or — from the mean, of the members may be expressed in percentages of the mean; and a mean may be usefully supplemented by a figure showing what proportion of the members of the series differ from it by a relatively small quantity. The *mean error* may be calculated by (1) finding the mean of all the members which are *above* the general mean of the whole series and subtracting the general mean from it, the + mean error being thus obtained; (2) finding the mean of all the members which are below the general mean and subtracting it from the general mean, the — mean error being thus obtained. The two numbers added together and divided by 2 give the mean error.*

Fallacies of Averages.—Supposing that each of the numbers upon which an average is computed be in itself reliable, and that those numbers be sufficiently numerous to yield a good average, yet the average may be a comparatively worthless and misleading expression, because the difference in the numbers is great. It may be that not only the extremes are great, but that none of the numbers is near the average. For simplicity we will take the average of two numbers; say that average is 50: the numbers on which it is founded may be very divergent, as 1 and 99, nearer, as 25 and 75, very close to the average, as 49 and 51, or even identical with it. Hence the advisability of stating extremes, and, if they diverge much from the average, of adding a statement showing the degree in which the numbers approximate to the average. The units composing an average may aptly be compared to the marks of rifle-bullets on a target: in the most valuable and representative average they will *all* be close to the centre, in

* The quadratic mean error is a better test, but is more troublesome to calculate. *Vide* H. King's *Manual*, para. 847. Radicke's method of *successive means* is also useful in ascertaining the value of a mean.

a less valuable average they will be more or less scattered, extremes being perhaps very far from the centre, and in the least valuable kind of average they will be nearest to the margin of the target. We will now turn to some common errors in practical statistics connected with averages.

The average of ratios is often computed in a manner which is extremely erroneous, the average being reckoned on the mere ratio-numbers, forgetting that such numbers may differ largely in *weight*. The relative *weights*, for instance, of death-rates are in proportion to the relative numbers of the populations to which they refer.

If the populations are equal, the mean of their death-rates is the true mean death-rate of the whole; and, if the death-rates are equal, the same death-rate is true for the whole. But if the populations are unequal and have different death-rates, the simplest method of calculating their combined death-rate is to reckon the rate on the sum of the populations and the sum of the deaths. For example, suppose three populations as follows:—

Population.	Deaths.	Death-rate.
24,780	510	20·6
30,615	649	21·2
101,912	4,159	40·8

The combined or average death-rate of the whole population is not the arithmetical average of the death-rates of its parts $\frac{20{\cdot}6 + 21{\cdot}2 + 40{\cdot}8}{3} = 27{\cdot}5$, but $\frac{5{,}318 \times 1{,}000}{156{,}370} = 34$.

A correct reckoning of *average strength* is important for obtaining true rates in the case of shifting and variable populations, such as those of troops, jails, schools, and works where the number of men varies. The average strength is the sum of the numbers present each day divided by 365, the number of days in the year.

In calculating annual rates when the population was present for only a part of the year, the same rule must be observed; for instance, if the place was occupied for only 160 days, the sum of the daily population for these days must still be divided by 365 to give the average *annual* strength and the rates (taking the sum of the *local* events, such as deaths) must be calculated on this to obtain annual

rates. Rates should on no account be calculated on "total population," (*i.e.*, number present at the beginning of the year + admissions during the year). "A total population of 365 might mean 365 persons in residence throughout the year, or 365 entering on the last day of the year, or 1 entering daily." *

Arrangement of Statistics.

The method of arranging statistical facts is only second in importance to their correct compilation. The facts when intended for general use must be presented in a readily comprehensible form, because ill-educated persons, and even well-educated persons who are unacquainted with statistical methods, will fail to draw correct inferences from figures which they understand imperfectly or improperly.

Statistical facts may be stated (1) numerically, (2) graphically, and (3) numerico-graphically. The first method consists of simple statements of numbers, such as sums, ratios, or averages.

The graphic method consists of the representation of statistical results by lines, spaces, colors, shading, &c. Thus lines of various length or spaces of various size may be drawn to scale in the ratios of numbers representing facts which it is intended to compare together, and such lines or spaces may be colored to distinguish them more vividly. The geographical distribution of certain facts may be shown by maps variously colored or shaded.†

The numerico-graphical method of arrangement is most frequently employed and most convenient for general purposes. It includes the use of tables, curves, or lines combined with numbers, &c.

Fallacies of Comparison.—False inferences are very frequently made by comparing numbers which are not comparable, or which can properly become so only after certain corrections have been made. A few of the com-

---

* *Review of Bengal Jail Report*, 1885. *Indian Medical Gazette*, September 1886.

† Race or family characters of feature, which are not readily amenable to numerical expression, may be averaged by superposing feeble photographic images of individuals so as to produce a single picture. (F. Galton.)

monest errors are here noticed. Errors of comparison may arise in connection with primary numbers, ratios, or averages.

Primary numbers expressing certain variable facts in relation to other variable facts are sometimes wrongly quoted as though they were true ratios. It is obviously incorrect to compare totals (such as total deaths) affecting populations of different magnitudes; but it is also, though not so obviously, incorrect to compare totals affecting the same population at different periods. Thus an annually increasing number of deaths in a place does not at all warrant the inference that the place is becoming more unhealthy, nor does an annually diminishing number of deaths warrant the inference that a place is becoming more healthy; in the first case the population may be increasing, and in the second case it may be diminishing in a more rapid proportion than the deaths and its age-constitution may have changed. The use of primary numbers to express ratios is rarely justifiable; but they may often be usefully quoted to show the reliability of ratios calculated on them, or to impress persons unaccustomed to statistical inquiries with the magnitude of certain aggregate facts.

With regard to ratios errors are very often made by comparing the rates of differently constituted populations as to age and sex, or differing as to race, habits, occupation, and wealth. *All* causes of variation should be kept in view when ratios are compared with regard to particular causes of variation. Ratios calculated on insufficient numbers or for very short periods must never be accepted as true, especially for comparative purposes.*

The more representative an average is, that is the closer its constituent members approach it, the more valuable it is for comparative as well as for other purposes. It is unsafe to compare averages of which the "mean error" is large or from which the "extremes" are very divergent. If the difference between two averages be greater than the sum of the differences between each of them and its extreme † (the

* The incorrectness of ratios on population as calculated in all Indian vital statistics is elsewhere alluded to. No allowance is made for increase or decrease, but they are reckoned on the populations of the last census. The error thus tends to increase every year after a census, and to render such numbers more incorrect, whether as mere statements of fact or for purposes of comparison.

† This is I think a proper modification of *Radicke's* rule "that the difference must be greater than double the largest fluctuation."

difference in one case being + and in the other — or *vice versâ*), conclusions may safely be founded on this difference; but, in most cases, a much smaller difference may be accepted as practically conclusive.

POPULATION.

A correct knowledge of the composition of the population concerned is the first essential for statistical purposes. Exact information can only be obtained directly by a *census*.

Few populations, however, are stationary; it, therefore, becomes necessary to form *estimates* of population during the periods between censuses. This can be done accurately if complete returns of the number of births and deaths and of immigrants and emigrants are available; but in most places—practically all places in India—such returns are far too imperfect for the purpose.

Another method which gives generally correct results (and is employed by the Registrar-General of England) is therefore to be preferred. It is assumed that the rate of increase (or decrease) in a population remains constant, and the ascertained rate of increase during the period between two censuses is taken as the rate of increase during the next inter-censal period. Since the increments to population also increase, the calculation is evidently one of "compound interest." *

The mean population of the year (*i.e.*, population calculated to the middle of the year) should be taken for reckoning annual rates, &c.

---

* The "annual rate of increase" (the nth root of the increase in n years) of the population must first be ascertained. If P = population at first census, P′ = population at second census, r = annual rate of increase *per unit* per annum, and n = number of years between censuses; then $P(1 + r)^n = P'$; but n here = 10, hence, log. P + 10 log. $(1 + r)$ = log. P′, and 10 log. $(1 + r)$ = log. P′ — log. P ∴ log. $(1 + r) = \frac{1}{10}$ (log. P′ — log. P). Having obtained the value of r, the population after any number (n) years = $P(1 + r)^n$. Simply $\frac{1}{10}$ of the difference between the logarithms of two decennial censuses = logarithm of annual rate of increase, and this multiplied by the number of years since last census, added to the logarithm of population of last census = logarithm of present population.

The same equation supplies the means of calculating the number of years required for a population to increase to any given extent, in which case it is required to find the value of n.

It may be observed that in Indian vital statistics all rates are calculated upon the *uncorrected* population according to the last census. A needless error, which increases every year after a census, is thus added to their admitted faultiness. The annual rate of increase of the population of the Madras Presidency has been calculated to be 7·83 per 1,000 per annum.* In town or district statistics corrections should be founded on the local changes of population.

Census.

The first census of India was taken in 1851, and thereafter quinquennial censuses were taken until 1871, when a decennial interval was adopted. Decennial censuses have been taken in England since 1801. A shorter interval would be advantageous, because *estimates* of population made many years after a census are often erroneous to a considerable extent, and because it would conduce to greater accuracy of each census, the people being more accustomed to the inquiry, and a larger number of experienced persons being available as enumerators.

Besides a mere enumeration of the population, much valuable information as to its composition and its social condition is elicited by a well-planned census; and successive censuses exhibit the changes in a population. The following are the most important inquiries which are made: age, sex, occupation, conjugal condition, infirmities, number of inhabited houses, density of population. Of less importance, from a sanitary point of view, are education, religion, race, caste,† language, birth-place.

Age.—One of the most essential requirements in vital statistics is to know the age-composition of populations. Without any intentional misrepresentations two kinds of error have been found to prevail in age statements: the age of infants is apt to be over-stated, infants *under* one year being returned as one year old, under two years as two years old, &c., the infantile population thus tending to appear

* G. Stokes. This is probably too low an estimate (little more than half the English rate); but corrections ought at least to be made on this basis. In the decennium 1872–81, in the six districts most remote from famine influence, the increase was 10 per cent. All India (excluding Madras on account of famine) showed an increase of 9·16 per cent.

† With regard to this subject the Report on the Madras Census of 1871 by W. R. Cornish contains the most complete account which has been written.

less numerous than it really is; and adults are apt to have their ages given in round numbers as 30, 40, 50, &c. Clear instructions and care on the part of enumerators ought to reduce the first error; the second is, to a great extent, obviated by adopting age-groups of 25–35, 35–45, &c.,* instead of 20–30, 30–40, &c.

The age-constitution of a population depends upon the birth-rate, death-rate, emigration and immigration. Emigrants are generally young adults; emigration, therefore, generally exerts an unfavorable and immigration a favorable influence on the age-constitution of a population. When the birth-rate of a population is continuously higher than its death-rate, the population not only increases, but its age-constitution is so affected that it possesses a larger proportion of individuals at the lower ages than a population which is not increasing or is increasing at a slower rate.

Populations of different age-constitution cannot be properly compared with one another unless due allowance be made for the difference. For instance—to take an extreme case, but one not unknown—it is absurd to compare, without correction for age-distribution, the mortality among a body of young people, such as school children, or of adults, such as workmen or troops, with the mortality of the general population. In comparing urban with rural populations, or even town populations with one another, differences of age-constitution should be taken into account, if they be at all considerable. A knowledge of age-constitution is also very important in estimating the value of hygienic measures and for various other sanitary statistical purposes. In English statistics it is generally stated in quinquennial groups from 0 to 25, and decennial groups from 25 to 75, above 75 forming a single group.

The age-distribution of the population of the Madras Presidency in 1871 † is here shown per 1,000 persons living:—

All ages.	0–5	5–10	10–20	20–30	30–40	40–50	50–60	60–70	70–
1,000	163	138	224	169	125	86	46	21	28

* Farr.

† 1881 is not taken on account of the disturbing influence of the famine of 1877.

This may be compared with the following age table for England (1881):—

All ages.	0–5	5–10	10–15	15–20	20–25	25–35	35–45	45–55	55–65	65–75	75–
1,000	136	120	108	98	90	146	113	84	59	33	13

The economic value of a population largely depends upon its age-constitution: other things being equal in two populations, it is manifest that the one which possesses the larger proportion of individuals at working ages (15 to 50) has material advantage over the other.

Sex.—The sex-constitution of a population is important in particular cases when it differs much from the normal. The marriage, birth, and death-rates are influenced by it. In the Madras Presidency nearly 103 males are born for every 100 females born; * but here, as in every other country, the mortality of males at the earlier (under 5 years) and later ages (over 35) exceeds that of females, so that the population normally contains more females than males in the proportion of 102 to 100.†

Mixed populations differ so little from one another in sex-constitution that no correction need usually be made on this account when comparing of their death-rates, &c.

Occupation has very considerable influence upon health. As a rule town and sedentary occupations have a deteriorating influence when compared with country and active occupations. Agriculture is the pursuit of the great majority of people in India. The percentage of the agricultural to the total working population in India (1881) is 64, in the Madras Presidency 65·2, and in England (1871) 15·4.‡ In Madras, the agricultural forms 35·4 per cent. of the total population, and 67·14 per cent. of the male workers are agriculturists, about 4 women to 7 men being engaged in agriculture.

* The mean corrected birth-rates, according to Mr. G. Stokes, being for males 43·11 and for females 41·90. The experience of the Madras Lying-in Hospital, however, (1873–82) in 13,544 births gives the proportion of male to 100 female births as before the famine 115, during the famine 98, and after the famine 111.

† According to 1881 census.

‡ In Ireland the proportion approaches that of India.

The following table* gives a comparison of the class-composition of the Madras and English populations :—

Class.	Madras.	England.
Professional	4	7
Domestic	1	3
Commercial	3	11
Agricultural	67	20
Industrial	19	49
Laborers, &c.	6	10
Total ...	100	100

The above classes should be largely sub-divided. To ascertain the effect of occupation on health, the mortality from different causes, as well as the total mortality, should be known. The mortality at different groups of ages should also be ascertained. In comparing the death-rates of persons engaged in particular trades or callings, it must not be forgotten that persons are so employed during working ages, and that the age- and sex- composition of the different groups is likely to differ largely and needs to be taken into account.†

Conjugal Condition.—The following figures are from the *Madras Census Report,* 1881. Of the total population 45½ per cent. were single, 42 per cent. married, and 12½ per cent. widowed :—

—	Single.		Married.		Widowed.	
	Men.	Women.	Men.	Women.	Men.	Women.
All India	48	32	47	49	5	19
Madras	55	37	41	42	4	21
Madras over 15 years of age.	26·5	5·3	67·2	60·9	6·3	33·8
England over 20 years of age.	27·1	25·8	66·1	60·6	6·8	13·6

* *Madras Census Report,* 1881.

† Dr. Ogle has prepared valuable occupational statistics for England, of which an extract is given in Newsholme's *Vital Statistics,* 1889. The

In Madras 173 per 10,000 men under 15 years of age were married; in England only 11 per 10,000 men under 20. In Madras 1,132 per 10,000 women under 15 were married; in England only 67 per 10,000 women under 20. In Madras only 5·3 per cent. of women over 15 were single, while in England 25·8 per cent. of women over 20 were single. These figures show that the great difference between the conjugal condition of the people of India and that of the people of England (and other European countries) consists in the comparatively very early marriage of the former.* In England the average age at marriage (1887) is for men 26·2 and for women 24·7 years; and one-fifth of the people who attain a marriageable age never marry. In England the lowest, poorest, and the least-educated classes marry earliest, and the socially highest and best-educated latest, the average age at marriage in the professional and independent class being 31·22 years for men and 26·4 years for women; but, even in the lowest classes, marriage is influenced by prudential considerations, and the marriages become fewer and later when prosperity diminishes. In India no prudential motives have, even

---

following instances will suffice to show how much mortality is influenced by occupation. They indicate the annual death-rates per 1,000 of males (1880–82):—

Occupation.	Age, 25–45.	Age, 45–65.
Clergymen	4·64	15·93
Farmers	6·09	16·53
Agricultural laborers ...	7·13	17·68
Builders and bricklayers ...	9·25	25·59
Carters and carriers	12·52	33·00
Inn-keepers and publicans ...	18·02	33·68
General laborers (London) ...	20·62	50·85

* Some of the evil results of unrestrained early marriage have been already noticed. The ancient Greeks excelled in their admiration for, and cultivation of, physical perfection, and it is noticeable that Aristotle considered that men should marry at the age of 37 and women at 18, and Plato that men should be from 25 to 55 and women from 20 to 40.

in the educated classes, outweighed the power of *custom*, which enforces marriage at the earliest possible age.

The marriage-rate and age at marriage are most important as influencing the birth-rate of a population, the fecundity of early marriages being greater than that of later ones.* Earlier marriage must tend to increase population, even if the number of children to each marriage be not increased, for the intervals between generations will be diminished.

In a population where late-marriage and a considerable amount of celibacy prevail, natural selection has much more important play in improving the race than in a population where all women marry at the earliest possible age and celibacy is practically unknown. In the former population many weakly persons die between the age of puberty and the usual marriage age—persons who would have married in the latter population; and selection has considerable scope among those who survive, many remaining unmarried.

Infirmities.—According to the census of 1881 the following were the proportions to population of the infirmities enumerated :—

Lepers, 1 in 2,132.	Deaf-mutes, 1 in 1,810.
Blind, 1 in 611.	Lunatics, 1 in 2,993.

In 1871 the proportion of lunatics was 1 in 2,222, the loss in 1881 being attributed to their greater mortality during the famine.

The number of inhabited houses affords some indication of the extent of overcrowding in houses and a means of making future estimates of population. It is found that the mean number of persons per inhabited house remains fairly constant in the same population; enumeration of inhabited houses, therefore, affords a check on estimates of population made at intercensal periods, and it affords the best method—short of a census—for estimating the

* Dr. M. Duncan found the average fecundity of women marrying at 15–19 years of age was 9·12, and it progressively diminished as ages advanced, being 4·6 for those marrying at 30–34 years. $\frac{\text{Births}}{\text{Marriages}}$ = mean fecundity per marriage.

number of a population which has been much affected by migration.*

Overcrowding in houses is no doubt a great cause of disease and death; but it must be borne in mind that the greatest overcrowding occurs among the most indigent, who live in other respects also under the most insanitary conditions.†

Density of population for general or country populations is usually stated as number of persons to each square mile, and for towns as number of persons to each acre. It may also be reckoned by making area the variable factor and calculating the number of acres or square yards to each person.‡

The number of persons per square mile was, in 1881, in the Madras Presidency 221 (extremes being Tanjore 583 and Kurnool 91), Bengal 457, North-West Provinces 416, Burma 43, England 447.

In country districts the density of population has usually little or no effect on health and mortality. In India indeed increased density in country districts may conduce to an improvement of public health by causing the removal of unhealthy scrub and the cultivation of waste lands.§

It is in towns that density of population has particularly obnoxious effects. The following statements may be taken as axioms:—(1) Other things being equal, the bigger the

* In 1881 the number of persons per occupied house was highest in Madras City (8·4) and South Arcot District (7·4) and lowest in Cuddapah District (4·5). The mean for the Madras Presidency was 5·5, towns 5·8, villages 5·4.

† Dr. J. B. Russell, of Glasgow, has compiled some valuable statistics on this subject (1888), which show that mortality diminishes greatly as size of house increases.

‡ $\frac{\text{Population}}{\text{Area}}$ = mean population per unit of area, and $\frac{\text{area}}{\text{population}}$ = mean area to each person.

§ I may here take exception to a statement in the Madras Census Report, 1881 (Appendix A), that in the Madras Presidency there is no rural population properly speaking, that is dwelling in detached houses. "Every village is as closely packed, as unclean, and as prejudicial to health as the largest city." The majority of the rural population in all countries dwell in hamlets and villages; and lamentably bad, as is the sanitary condition of Madras villages, I do not think they can be compared, as to filth and overcrowding, with the very poor quarters of large towns. They certainly have the great advantage of comparatively pure air outside of the houses. Statistics, so far as they go, indicate that in India as elsewhere rural populations are healthier than town populations in almost every respect except their greater liability to malarial infection.

town in population, the greater is its mortality, and (2) other things being equal, the larger the town in area, the less is its mortality.

In towns many causes of disease exist from which villages are comparatively free. The poor and the dissolute are attracted to towns in search of food, or money, or dissipation. Temptations to the adoption of unhealthy practices are greater. Every nuisance and every case of communicable disease becomes a greater danger as the population is larger. Cleansing is more difficult, and, if it is not well performed, pollution of soil and air are more extensive. If there be no public water-supply from without, the contamination of drinking water is greater. Different classes are apt to congregate in different localities; and thus the poorer quarters of large towns teem with a concentration of vice, misery, filth, and disease. To all these and other evils are dwellers in towns exposed; and we need not wonder that they should generally suffer from sickness and mortality to a larger extent than do the inhabitants of villages.

But the inhabitants of towns have some great sanitary advantages; and, when they have the knowledge and energy to use these advantages, they may rival or surpass countrymen in healthiness.*

If poverty tends to concentrate itself in towns, so does wealth tend to accumulate in them. If large communities breed dirt, so do they afford means for its removal; if they harbor pestilence, so can they combine to suppress it. They can command skilled advice and the means for acting upon it. They can bring pure water from a distance, or build works for its purification; they can construct and maintain well-made sewers, drains, slaughter-houses, latrines, markets, hospitals for infectious diseases, cremation or burial-places, and sewage-farms, and can manage a public system of cleansing and lighting. They can make and enforce regulations as to the sanitary construction and maintenance of houses, the sale of wholesome food, the isolation of infectious diseases, and many other matters connected with the public health and well-being.

Large towns may thus do much towards sanitation, which is beyond the knowledge or the means of individuals or of

* The considerable reduction of mortality in England in recent years has been due almost entirely to sanitary improvements in towns.

small communities; and, with vigorous administration and the assistance of loans for large public works, Indian municipal towns ought to make rapid strides in reducing their present unhealthiness.*

Registration of Births and Deaths.

An accurate registration of births and deaths, with subsidiary particulars, is as necessary to the sanitary statist as an accurate knowledge of population obtained by census.

In India generally such registration has hitherto been extremely imperfect and unreliable.† Recent legislative enactments, *if enforced*, will no doubt improve it in municipal towns; but it will be long before district registration can become satisfactory. In the city of Madras registration is compulsory under a penalty of Rs. 20 for default (section 402, Madras Municipal Act, 1883). In the District Municipalities Act, 1884, though provision is made for registration, there is no penal clause; but a penalty may be provided for in bye-laws under this Act. In the Local Boards Act, 1884, the subject of registration is not mentioned.‡

So long as registration of births and deaths is imperfect, it will be impossible to form exact judgments as to the sanitary needs of communities and as to improvements in their condition.

The most necessary particulars required in registering births are date, sex, nationality or caste, profession of father; and in registering deaths, date, age, sex, cause of death, profession, residence.§

* The death-rate of Madras town for 1884–88 was 39·9. The death-rate for Calcutta *suburbs* was in 1886 40·5, and in 1887 42·2. That of Peshawar (1886) was 48, Amritsar 44, and Delhi 42. That of Calcutta (Central) in 1886 was 26·4, and in 1887 25·3.

† Mr. G. Stokes (in 1881), by comparing the Madras town with the presidency statistics, estimated that the rate of omission in the birth returns was no less than 2·177, *i.e.*, for 100 births returned 218 occur! For deaths he reckoned the rate of omission to be 2·202 under one year and less at other ages.

‡ District registration is performed by revenue officers—village *karnams*. It ought to be regarded as a very important part of their duties; and, if severe notice were always taken of its neglect, district returns would be much better than they are. When the registered death-rates are below 30, and birth-rates much below 40, deficient registration may be suspected.

§ *Vide* forms prescribed in Schedules L and M of Madras Municipal Act.

Still-born children should not properly be included in either the birth or death registers, but a separate register of them should be kept.

The *cause of death* is a very important particular, and one which it is often difficult to obtain with accuracy, even in countries where registration is otherwise good. The reasons for this are difficulties in the classification and nomenclature of diseases and faulty *diagnosis*.* When causes of death cannot be ascertained by registrars, they should be marked "not known."

Births.

The mean Madras Presidency birth-rate † is 42·45 per 1,000 of population, the rate for males being 43·11 and for females 41·90.

In comparing the birth-rates of two populations, their age and sex composition must be taken into account if they differ much. An approximate correction for differences in age and sex composition may be made by calculating the birth-rates on the female population at child-bearing ages instead of on the general population.

Causes which increase the birth-rate are early marriage, favorable age-constitution of population (a large proportion of the women being of child-bearing ages), favorable sex-constitution of population (the normal proportion, or, in polygamous societies, an excess of women), and abundance of food.

In India, since all women practically begin child-bearing at the earliest possible age, the birth-rate is always the highest possible; and were it not for the high rate of mortality, especially the enormous infantile mortality,‡ the

---

* The appointment of skilled medical registrars was, therefore, advocated by Farr.

† For 1870-76, corrected by G. Stokes. The true birth-rate is possibly higher, but this is the most accurate figure obtainable at present. A birth-rate as high as 50 has been registered in the Gurdaspur district of the Panjab.

‡ In Madras city more than 30 per cent. of the children born in 1887 died in their first year. In England less than 15 per cent. die in their first year. The official statement of the infantile death-rate in Madras for 1887 was *517 per 1,000!* This, however, was improperly obtained by the customary local practice of calculating it on the census returns of infant population instead of on the births of the year.

population would increase at an extremely rapid rate *—a rate impossible in a settled, populous, and mainly agricultural country, for the means of subsistence could not increase so fast.

As a matter of fact the doctrines of Malthus do apply very closely to Indian populations. These populations constantly tend to increase up to the limits of means of subsistence. In prosperous times they increase very rapidly; and, having no reserve of means, when hard times come, they succumb by millions. A large proportion of them live habitually in a condition of semi-starvation. Pestilences are always rife among them. Insanitary conditions slay the great majority of their children—children who should never have been born—whose lives, before and after birth, are a useless drain on the strength and resources of their parents.

People, like this, who multiply after the manner of wild animals and plants, cannot but share the fate of wild animals and plants: "each, at some period of its life, during some season of the year, during each generation or at intervals, has to struggle for life and to suffer great destruction." † Improvement is difficult while such conditions endure, except that low form of improvement—or degradation—consisting in adaptation to, and survival of the fittest to live under, depraved circumstances.

This excessive (highest possible) birth-rate is the greatest obstacle to sanitary improvement in India. While the people continue to beget more children than they can rear‡ or the country can support, chronic poverty, with its concomitants of dirt, disease, and famine must prevail among them. It is no doubt true that sanitary measures may, in some places, largely reduce the present high mortality. But what must be the effect of such a reduction of mortality while the present birth-rate continues? What must

* It would double itself in 29 years if the rate of mortality were the same as the English rate.

† Darwin: *Origin of Species.*

‡ It is a constant occurrence that men in search of employment or promotion declare themselves to be "poor men with large families," and this is generally true. In populous countries poor men have no business to have large families—their having them is a social crime and the origin of much misery. A man might as logically ask for assistance because he had lost his health by intemperance in drink or food or been beggared by gambling as because he had begotten a large family. Pity for the children may be laudable—their self-indulgent and reckless parents deserve none.

be the effect of a too rapid rate of increase in the population of agricultural and already fairly populous countries?

Supposing only a comparatively small decline in the present death-rate were to take place throughout the country, the continuance of the present birth-rate would cause the population to increase at the same rate as that of the English population—a manufacturing and emigrating population with a large reserve of accumulated wealth and the "prudential check" of later marriage when prosperity diminishes. And will agricultural India be able to feed double her present population even fifty years hence? With the present birth-rate, will not a diminution of mortality in one place mean increased poverty and mortality later on, or else migration and increased poverty and mortality in other places? *

Does not this inelastic and extreme birth-rate, which is controlled only by famine, prevent any material reduction in the general death-rate of the country?

It may, I think, be laid down as a general axiom that *the increase of a healthy population is governed by its birth-rate;* that is, the death-rate, having been reduced by good sanitation to nearly its lowest possible level, remains nearly stationary, but the birth-rate is kept under rational control † and is the changing factor which regulates the rate of increase of the population in proportion as circumstances favor such increase, and may cause the population to remain stationary or to decrease when conditions become less favorable. *In India the increase of the population is governed largely by its death-rate,* this being the more variable factor, while the birth-rate remains comparatively stationary. In the former case the "prudential check" (of Malthus) comes into play, that is, the increase of population is regulated by *reason;* in the latter the "misery check" holds sway, that is, the increase of population is restrained by *nature.*

* The death-rate in Calcutta has lately been reduced by more vigorous sanitary administration under an able Health Officer (Dr. Simpson); but the death-rate of its suburbs has increased:—

	1886.	1887.
Calcutta	26·42	25·32
Suburbs	40·51	42·17

† In England half the women of child-bearing ages are unmarried, and the births are thus kept down to half their possible number.

Certain variations in Indian birth-rates do occur, however; and they are due mainly to the same causes which produce natural variations in the death-rates (apart from sanitary improvements), namely, abundance or deficiency of food. Abundance of food increases the procreative power and deficiency diminishes it. Prosperity, therefore, tends to a rapid increase of population by acting in two directions, raising the birth-rate and lowering the death-rate; while, conversely, adversity puts a double check on population.*

The early marriage question is at the root of the terribly high birth-rates which thwart sanitation in India, and of the poverty and much of the unhealthiness in which Indian populations are plunged. This is a social question and one for agitation among the people themselves. Native philanthropists have here in truth a large evil to engage them, and one which is worthy of their most strenuous and persevering endeavours to alleviate.†

Early marriage increases the birth-rate in three ways: by producing a larger number of children per marriage, by diminishing the intervals between generations, and by producing a favorable age-constitution of population.

Birth-rate and age-constitution exert a mutual influence upon each other. A continuously high birth-rate produces

---

* An Indian population is more *sensitive* than a European one, both to prosperity and to adversity, because in the former there is always a large proportion of persons in want or on the verge of it, and all women of child-bearing ages are already married.

† In considering the effects of this continuous highest-possible birth-rate, one might well feel disposed to adopt the most pessimistic views of Malthus or of the Secretary to the Punjab Government (Review of Sanitary Report for 1885), or to feel the unintended satire in the advice of a late high official who recommended the people to become rich!

But the author is hopeful as to the gradual sanitary amelioration of the peoples of India; he is hopeful that, as sanitary improvements are effected, so will reasonable views as to marriage and propagation take root in the upper and spread to the lower classes, that the birth-rates will be brought more under control, and that they will diminish *pari passu* with the death-rates.

At the same time he feels convinced that until the effect of the very high birth-rate as a *block to sanitation* is fully recognised, and until births begin to diminish, no great reduction of the general death-rate is possible throughout the country. A sudden reduction of the birth-rate is not to be expected; nor is it to be desired, because under present insanitary conditions (which cannot be very rapidly ameliorated) the population might easily become a diminishing one and unhealthy tracts of country would be depopulated.

a population containing an excessive proportion of youthful and young adult members; and such a population is naturally productive of a high birth-rate, especially in India, on account of the early and general marriage of girls. A favorable age-constitution produced by other causes, such as a migration of young adults to a town, or a high death-rate, tends similarly to increase the birth-rate.

Deaths.

The mean corrected death-rate * for the Madras Presidency is 33·70 per 1,000 persons living, 33·91 for males, and 33·47 for females. In Madras city, where registration is comparatively good, the rate in 1888 was 37·8, its average for the five years ending 1888 being 39·9. Some very high death-rates were registered in some of the municipal towns of the presidency during 1888; for instance, Srirangam had a death-rate of 66 6, Gudiatam 78·0, Calicut 53·8, Tuticorin 49·2, Berhampur 48·2, Coonoor 42·6.

The death-rate is usually expressed as proportion per 1,000 living persons — $\frac{\text{deaths}+1{,}000}{\text{population}}$ — or as 1 in so many of population. $\frac{1{,}000}{\text{death-rate}}$ = number of population in which one death occurs; thus the presidency death-rate is 33·7 and $\frac{1{,}000}{33{\cdot}7} = 29{\cdot}67$, that is the deaths are nearly 1 in 30 of population; and $\frac{1{,}000}{\text{number to 1 death}}$ = death-rate.

To obtain the "weekly death-rate," that is the *rate per annum* of deaths occurring in a week, the number of deaths occurring in a week are multiplied by 52·17747 (exact number of weeks in year); this gives the total annual mortality corresponding to the mortality of the week in question and the death-rate is calculated upon this number in the usual manner. To simplify the calculation the "weekly population" is generally taken, that is $\frac{\text{mean population of year}}{52{\cdot}17747}$; and $\frac{\text{deaths in week} \times 1{,}000}{\text{weekly population}}$ = annual rate to which weekly deaths are equivalent.

Indian death-rates, as elsewhere noticed, are always erroneous, not only on account of defective registration, but because they are calculated on the populations of the previous census. The city of Madras had a population,

* As *estimated* by Mr. G. Stokes, 1881.

exclusive of Europeans and East Indians, on the 18th February 1881 of 389,984. The population corrected * to the middle of 1888 would be 413,389. The official and erroneous death-rate for 1888 is 37·8, the corrected rate being 35·7.

Large fluctuations in death-rates for short periods may be due to climatic causes, epidemics, or diseases which have a marked seasonal prevalence. Short-period rates should be reckoned only for large populations; else they are unreliable owing to an insufficient number of data. Weekly or monthly mortality statements are of great value for indicating sanitary changes which may not be evident and for estimating those which are evident. "The deaths serve the purpose of a self-registering inspection." (Farr.)

The *general death-rate* of a population is the most commonly employed test of its sanitary condition, and it is generally a reliable test.

The *sensitiveness* of Indian death-rates to sanitary conditions is remarkable; and their fluctuations are greater than those of European populations.† This sensitiveness may be attributed to several causes: (1) the low age-constitution of the population, which naturally favors a low death-rate; (2) the high birth-rate, infantile mortality forming a large proportion of general mortality and being notoriously sensitive to sanitary conditions; (3) the early marriage of all girls, which causes the population to breed up to its means of subsistence and renders it easily and extensively affected by want; (4) the high death-rate, which

* Taking Mr. Stokes' calculated rate of increase instead of that calculated on the decennium 1872–81, because of the effect of famine on the latter.

† The following are examples :—

Towns.	1884.	1885.	1886.	1887.	1888.
Madras	49·4	36·4	36·1	39·4	37·8
Cuddapah	41·8	24·7	31·7	48·9	37·1
Coimbatore	27·9	35·9	36·6	38·2	29·3
Trichinopoly	25·6	29·5	22·9	35·8	30·9

Some places show much larger differences, but as the rate increases progressively, these may be mainly due to defective registration.

is more easily and largely affected by favorable conditions than a low death-rate and conduces to a low mean age of population. Large fluctuations are commonly due to epidemics of cholera or small-pox and to outbursts of malaria due to excessive rain.

Special death-rates applied to separate causes of death and to separate sections of the population are of the greatest use in sanitary investigations. They show the effect of diseases, or of age, sex, occupation, locality, &c., on mortality, and by revealing the causes or particular incidence of high death-rates may enable defects to be pointed out and the efficacy of remedies to be estimated. A few of the more important special death-rates are noticed below.

The death-rate at different ages is a very important subdivision of the general death-rate. The presence of insanitary conditions, or of diseases which affect life at different periods, are thus made evident. Since the age-constitution of different populations may vary considerably, it is important that age-mortality should always be reckoned on the population at different age groups and not (as it is frequently and wrongly) as a percentage of total deaths; and the variations of the latter constitute a further reason for reckoning the deaths at particular ages on the population at those ages. The infantile (under 1 year) death-rate is best reckoned on the births of the year. The doubly fallacious method of reckoning infantile death-rates on the infantile population of the previous census is still adopted in Indian sanitary statistics. Thus the Madras town infant death-rate for 1887 is returned officially as 517·4 per 1,000; but the correct number is 330, because the births give the most accurate estimate of infantile population. In the following tables the Madras and English mortality at different age groups (annual deaths per 1,000 living at each age) are contrasted:—

England, 1871–80.

Ages ...	0-5	5-10	10-15	15-20	20-25	25-35	35-45	45-55	55-65	65-75	75-	All ages.
Males ...	68·14	6·67	3·69	5·23	7·32	9·30	13·74	20·05	34·76	69·57	160·08	22·61
Females	58·10	6·20	3·70	5·43	6·78	8·58	11·58	15·59	28·54	60·82	155·83	20·00

Madras, 1888.*

Ages	0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-60	60-	All ages.
Males ...	143·1	9·2	7·4	10·3	16·5	17·1	24·6	51·2	117·0	37·5
Females ...	132·3	11·2	8·8	18·3	18·0	17·8	19·2	36·3	127·2	36·7

Infantile mortality (deaths under 1 year to 1,000 births) in 1887:—England 145, London 158, Madras city 330. In 1888 the registered infantile death-rate in Madras was 327·3, being 334·5 for males and 311·5 for females. High infantile mortality is an invariable result of bad sanitation. In 1884, when there was an epidemic of small-pox in Madras, it reached 451·1.

The above tables show (1) that mortality differs very greatly at different ages, being much below the general rate between the ages of 5 and 45, and much above it under 5 and over 55; (2) that the mortality of the sexes shows sensible differences, the general death-rate of males being considerably higher than that of females, the male mortality being excessive under 5 and over 20 in England, and over 40 in Madras, increasing as age advances, while from 10 to 20 in England it is a little lower, and from 5 to 40 in Madras considerably lower than female mortality. Consequently the death-rate of a population will be lowered by an increased proportion of persons aged 5—45 and of females (and conversely). The excessive male mortality under 5 years occurs almost entirely in infants, and is attributed to the larger size and more difficult birth of males. The higher female mortality from 10 to 20 may be partly attributable to diseases of puberty, and it is undoubtedly increased by too early marriage; it is much higher proportionately as well as absolutely in Madras than in England. The excessive and increasing male mortality over 20 in England is apparently due to the greater hardships of men's lives.

Correction of death-rates for age and sex is manifestly necessary for correct comparison of the death-rates of different populations. In most mixed populations the pro-

* Deaths of 1888 reckoned on population of 1871, which was very little higher than that of 1881. The age-distribution of the latter was altered by the famine of 1877 and would be abnormal.

portion of sexes is so nearly equal that it is unnecessary to make any correction for sex; but in special cases it must be made. In comparing the death-rate of the population of the same place at different periods correction for age also is rarely required, because, in the absence of violent disturbing causes (as famine or migration), the age-constitution is not liable to rapid change. In mixed populations differences of age-constitution rarely occasion a difference exceeding 3 in their death-rates per 1,000. When the difference is much larger than this, correction for age is never likely to reverse the position, though it will state it more accurately.* It is in the case of special death-rates, such as those of troops or schools, that corrections for age and sex are most necessary, often essential, for comparative purposes.

The effect of public institutions, such as hospitals, jails, or lunatic asylums, in towns may be to perceptibly increase the death-rate. Persons in such institutions who do not belong to the place may properly be excluded from the general statistics of the population.

Places resorted to by pilgrims or other strangers may similarly have their death-rates affected if the deaths of such persons are included. On the other hand the presence of a considerable number of young students, or troops, or the influx of young adults into a town may lower its mortality. These, however, are taken into account in giving the age-distribution of the population.

The relation of birth-rates to death-rates is very important. Owing to the almost constant coincidence of high birth-rates and high death-rates, they have been by many authorities regarded as cause and effect. Their true relationship was expounded by Dr. Farr, who pointed out that a continuously high birth-rate naturally tends to produce an age-distribution of population which is favorable to a *low* death-rate, that is to increase the proportion of persons living at the lower ages (5–45) whose death-rate is naturally low.

The first effect of an increased birth-rate (*i.e.*, for first five years) must, however, be always to increase the death-

* Methods of correction need hardly be given here. The reader who requires information regarding them may consult the *Annual Summary for* 1883 of the Registrar-General (England), and Dr. A. Newsholme's *Vital Statistics*, 1889.

rate, owing to the increase of the infantile population among whom mortality is high.

But it cannot be doubted that a continuously high birth-rate in a population, when, owing to any cause, such as improvidence, idleness, ignorance or density of population, means of subsistence do not or cannot increase with commensurate rapidity, must cause indirectly a continuously high death-rate. In other words the "misery check" of Malthus must come into play. Ill-nourished mothers beget starveling children and suckle them with milk which is deficient in quality * and quantity; the infant mortality is thus easily increased, and poverty, overcrowding, and deficient food foster other insanitary conditions and conduce to a high death-rate at other ages. In these ways a high birth-rate does practically cause a high death-rate, although, at the same time, it may produce an age-distribution of population favorable to a low death-rate.

Causes of Death.—Statistics showing the causes of deaths are evidently of the greatest value for ascertaining the sanitary condition of a community and indicating removable insanitary conditions. In India for statistics of the general population the four principal causes of death alone are distinguished, two of these causes (cholera and small-pox) being specific diseases and two groups of diseases (bowel-complaints and fevers). The fevers, however, are almost all malarial. All deaths not included under one of these four causes are grouped together as "deaths from other causes," except deaths from "injuries," which are distinguished into deaths caused by (1) suicide, (2) wounds and accidents, (3) snakes and wild beasts.

Medical returns from hospitals, jails, and troops give a classification of deaths according to the *Nomenclature of Diseases* compiled by a committee of the Royal College of Physicians, London (revised 1885). This was founded upon, but differs in some respects from, the Registrar-General's method of classification. Classification of diseases is not, however, a question to be discussed here: what is of more immediate importance to us is the nomenclature of diseases; and in registering causes of death, it is important (1) to use

* Analyses of *famine-milk* were made by the late Mr. W. Hamilton and show *great* loss in this respect. Cornish: *Sanitary and Medical Aspects of Famine.* Appendix I, Report, Sanitary Commissioner, Madras, 1877.

only the names contained in the official nomenclature, and (2) to state the remote, rather than the proximate, cause, for instance death from pneumonia during an attack of measles should be returned as death from measles.

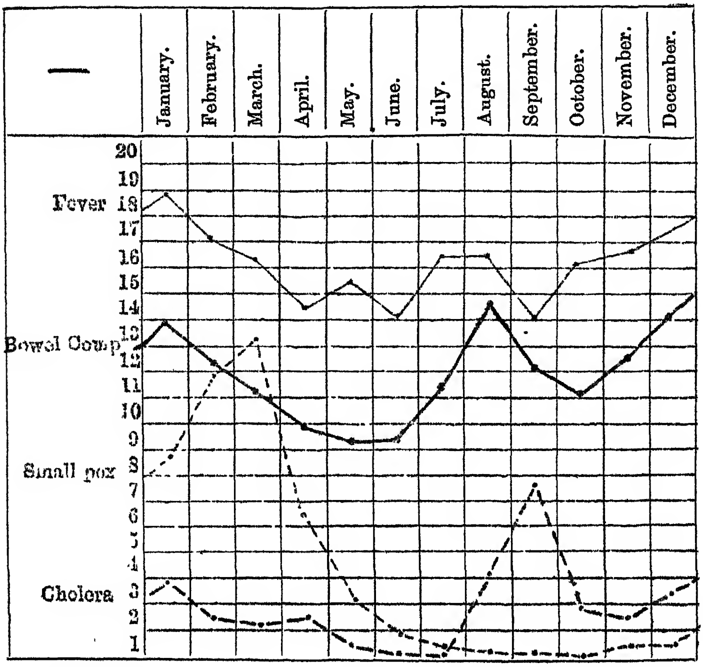
A complete and reliable registration of causes of death is impossible, unless all the deceased were attended or examined by competent medical men who can certify the causes. The time is approaching when such a registration may be attempted in some of the more advanced towns: at present it would be impossible. Some diseases occur only at certain periods of life, or prevail especially at certain periods. The mean age at death from such diseases is of medical interest, and the prevalence of such diseases in connection with the age-constitution of a population is of sanitary and statistical importance.

Deaths according to locality form an obviously useful distribution of the general death-rate, and may often serve as an indication or as a measure of local causes of unhealthiness. Local death-rates in districts of large towns may be employed for this purpose. The geographical distribution of endemic diseases and the course of epidemics may be traced with accuracy by local death-rates; and useful knowledge regarding their causation and prevention may thus be gathered.

Deaths according to occupation should be recorded by registration.* Occupational mortality has been already alluded to under the head of *Census*. In comparing the death-rates of different populations the possible influence of differences in their occupations should be borne in mind.

Deaths according to season give many useful indications, especially when deaths from special causes are so recorded. The following statement exhibits the seasonal mortality in Madras town from the four principal causes of death in the five years 1884–88. It is remarkable that the fever deaths show uncommonly little variation.

* A column for *profession* is contained in the form prescribed by the City of Madras Municipal Act.



The thin horizontal lines indicate hundreds of deaths up to 2,000.

Sickness.

Registration of sickness has hitherto been found impossible for the general population anywhere. It has only been effected in the case of public services, companies, societies, and institutions. From statistics of sickness thus obtained more or less trustworthy *estimates* of sickness among the general population may be framed when we possess good mortality statistics. Dr. Farr estimated that in England for every annual death which occurs, two persons are constantly sick; in other words, for one death there are two years of severe sickness.

Duration of Life.

Although the duration of an individual life is proverbially uncertain, yet the average duration of life in a large community of men is subject to very little fluctuation.

The *expectation of life at birth, the mean age at death, the number out of which one dies annually*, and *the number in which one annual birth occurs*, are identical for a permanently stationary population.* But practically no population is permanently stationary; and, in all real populations, the mortality (stated as one death in so many) and the mean age at death are not true indications of the expectation of life.

The mean age at death is a particularly fallacious guide in this respect, and it is only mentioned here in order that the reader may be warned against accepting it either as a test of sanitary condition or as an indication of the duration of life.†

Life Tables

are the only exact means for ascertaining the duration of life and the probabilities of death at birth or at subsequent ages. They are founded upon the number and ages of the living and the number and ages of those who die in a population, and represent "a generation of individuals passing through time."

A *life-table population* (which is of course hypothetical) consists of a number of individuals born at the same moment, and whose course through life is traced, the number dying in each year being recorded. Its statistics, therefore, are free from the errors attending those of changing populations.‡ Owing to the differences of male and female mortality separate life-tables for each sex are commonly prepared.

The principal indications obtainable from a life-table are: (1) age or past life-time; (2) annual mortality at each age; (3) probability of living one year from each age; (4)

---

* *Mean age at death* $= \frac{\text{sum of ages at death}}{\text{number of deaths}}$; $\frac{\text{population}}{\text{number of deaths}} =$ *number out of which one dies annually;* $\frac{1{,}000}{\text{death-rate}}$ also gives the latter. *The expectation of life at birth* (*mean after life-time*) is given in Life Tables.

† Space forbids a full explanation of this fallacy. Dr. Farr's and Dr. Newsholme's *Vital Statistics* may be referred to. Variations in age and sex constitution are the principal factors concerned.

‡ For methods of construction of Life Tables Dr. Farr's *Vital Statistics* or the chapter on Life Tables in Dr. Newsholme's *Vital Statistics* may be consulted. Mr. G. Stokes has prepared a Madras Life Table, but the data on which he worked were very imperfect.

number born and living at each age; (5) mean population in each year of age; (6) years which the persons at each age will live; (7) mean after life-time at each age.

The mean duration of life,

which is the most reliable test of sanitary state, is identical with the *mean after life-time from birth* or *expectation of life.*

When no life-table is available the *mean duration of life* may be obtained approximately from the birth and death-rates by the use of Farr's formula $\left(\frac{2}{3} \times \frac{1}{d}\right) + \left(\frac{1}{3} \times \frac{1}{b}\right)$ —b being the birth-rate and d the death-rate per *unit* of population. For instance the corrected Madras birth-rate (as given by Mr. Stokes) is 42·4 and the death-rate 33·7; therefore $\left(\frac{2}{3} \times \frac{1}{\cdot 0337}\right) + \left(\frac{1}{3} \times \frac{1}{\cdot 0424}\right) = 27{\cdot}6$ years, which is approximate mean duration of life in a Madras population. In England the mean duration of life is 43 years.

CHAPTER XII.

SANITARY LAW.

THE first duty of the State is the protection of life. The protection of health is a closely allied duty. Immeasurably more destruction of life, more misery and greater economic loss are caused, even in the healthiest countries, by the incessant attacks of preventable diseases than by the most disastrous wars or the most widespread brigandage. Reasonable persons, who at once admit the necessity of State legislation and taxation to secure the blessings of internal and external peace and as much individual freedom as is compatible with the general weal, yet are often blind to the necessity of legislation and taxation to protect their lives and their health from death and disease.

This is the blindness of ignorance; and unfortunately sanitary legislation cannot be thoroughly effective if it is too far in advance of popular ideas. Sanitary legislation must therefore be accompanied by a better knowledge of sanitary principles on the part of the public, especially the educated classes, as well as on the part of legislators and administrators. In England "the success of the Public Health Acts, 1872–75, has been very great and . . . . . . has been progressive from year to year. The reason is obvious . . . . . . wise and moderate provisions were loyally accepted by the public." *

In India sanitary legislation must of necessity be greatly in advance of popular ideas and education, and be sometimes opposed to old-rooted prejudices and time-honored habits; and those who possess a modern education are not always those who have most influence with the illiterate masses. Here therefore the difficulties of the sanitary legislator, and far more the difficulties of the sanitary administrator, are immensely increased.

* W. Carter, M.D., LL.B., *B.M.J.*, 1884.

To ensure the success of a sanitary law the people must in some measure be educated up to it, so that they shall have an idea of its purport. The great value of *permissive legislation* is that it thus paves the way for more stringent and effective laws.

Recent Indian legislation has conferred very extensive powers upon local bodies. Until these bodies have shown themselves capable of wielding such powers efficiently, and the people more fully recognise their value, there can be little need for more extensive powers. Lacking, as we do, and must do for a long time to come, a sufficient number of properly-educated sanitary administrators, efforts should be directed to their training, and to the sanitary education of the people under them, as the best means of rendering present laws effective. Heretofore these laws have been, as a rule, notoriously ineffective.

The main purposes of sanitary legislation are :—

(1) to protect individuals and communities from injury to health by their neighbour's faults (including necessarily restriction of their own malpractices) ;

(2) to make provision for the joint execution of large sanitary enterprises.

The following abstracts of those parts of local Acts which deal directly with sanitation may be found useful for reference :—

THE CITY OF MADRAS MUNICIPAL ACT.

(*Madras Act I*, 1884.)

Sect. 34. The President is the chief executive officer.

39. One Vice-President is in charge of all municipal works and the conservancy and sanitation of the city, except such as may be assigned by the President to the Health Officer, if any.

64. Government may compel the Commissioners to perform duties imposed on them by this Act.

138 *et seq.* provide for the levy of a water-tax on buildings and lands.

145. Waste or misuse of water punishable by fine of Rs. 20.

212. The Commissioners must provide a continuous supply of wholesome water and erect stand-pipes, fountains, reservoirs or pumps, at such distances that, in the populous parts of the city, no house shall be further than 150 yards from one.

Sect. 213. Water may be supplied to buildings.

215. Supply channel to be fenced.

216. Penalty of Rs. 20 for trespass on premises connected with water-supply.

225. Fouling of water by offensive trades punishable by a fine of Rs. 1,000, and Rs. 500 each day for continuance of offence.

227. Commissioners may provide or set apart bathing places and tanks or reservoirs or runs of water for washing animals or clothes.

228. Whoever in any manner fouls any public or private source of drinking-water is punishable by a fine of Rs. 50.

229. A fine of similar amount is leviable for washing an animal or clothing in a place set apart for bathing; or for washing cooking utensils, wool, skins or other foul or offensive substances in a place set apart for washing clothes or for bathing, or polluting such water with any filth.

230. Owner of private tank, well or other source of drinking-water may be required to keep and maintain it clean and in good repair.

231. Owner may be required to close or fence a well or tank, the water of which is unfit for drinking.

232. On refusal the President may execute the needful works.

233 *et seq.* treat of the construction, paving and repairing of streets.

254. Commissioners to provide and maintain a system of drainage.

258. Drains and sewers must not be a nuisance or injurious to health.

259. Sewage may be conveyed to convenient depôt and may be sold.

261. No building to be erected over a sewer without the consent of the President.

265. Notice to be given to the President of any new building or restoration, with plan of dimensions, level of foundation and of ground floor, statement of means of ventilation, drainage and privies, and such further particulars as may be required under bye-laws.

266. In case of disapproval President to state his views.

271. No block of six or more huts may be built without the permission of the President, who may require such huts to be built in a regular way and with due provision for sanitary requirements.

Sect. 273. The President may compel the owner of any building which is not properly drained to drain it into a public sewer or drain, if such be within one hundred feet.

277. All branch drains, private privies, cess-pools, &c., shall be under the control of the Commissioners and be kept in order at the cost of owners. In case of neglect President may cause work to be done and recover expense.

280. Every owner or occupier of a building or a block of six or more huts must provide and maintain such latrines as the President may direct, under a penalty of Rs. 50 and Rs. 10 per day for default.

281. A similar penalty is imposable for not providing and maintaining proper latrines and urinals in places where over twenty workmen are employed.

304. President must provide for regular cleansing of streets,

305. and suitable rubbish depôts,

307. and sufficient dust-bins in the streets for the reception of ashes, kitchen-refuse and other inoffensive matter. Building, stable and garden-refuse must be removed by the owner. Penalty of Rs. 10 for deposit of rubbish except in dust-bins.

308. Night-soil to be removed in covered vehicles and depôts provided for it.

309. The President may require all occupiers of buildings to provide movable private receptacles of a specified kind for night-soil.

313. Penalty for keeping filth on premises more than 24 hours, Rs. 50 and Rs. 10 for each day.

314. Penalty of Rs. 10 for allowing sewage to flow into street.

317. Penalty of Rs. 50 for throwing rubbish into or obstructing sewers or drains.

318. Penalty for not preventing child under 12 from committing nuisance in street, Rs. 5.

319. Public latrines and urinals to be provided by President.

321. Penalty of Rs. 50 and Rs. 10 per day for allowing any building or land, after notice from the President, to remain in a filthy or unwholesome state or overgrown with noxious vegetation.

322. Power to enter and order cleansing of buildings.

323. When obstruction is caused to drainage, ventilation or, cleansing, by crowding together of buildings, the President may require necessary works to be done or buildings to be pulled down.

324. The President may obtain an order from a Magistrate to abate overcrowding in buildings.

Sect. 325. Injurious wells or stagnant pools must be drained or filled up or cleaned, wells to be filled up only with clean soil.

326. In the case of private tanks or wells owner may be required to do this.

328. Watering of streets.

335. Livery stables, cart-stands, cattle yards, &c., must be licensed.

336. Penalty of Rs. 10 and Rs. 5 per day for keeping pigs so as to be a nuisance.

337. Stray pigs may be destroyed.

343. Bake-houses must be licensed.

345. Commissioners must provide slaughter-houses.

346. Slaughter-houses must be licensed.

347. License required and fee for each animal slaughtered.

352. Commissioners may provide markets,

354 and make bye-laws for their regulation,

359 *et seq*. private markets must be licensed and be properly kept.

367. Power of entry to examine articles of food or drink and to detain them if unwholesome. Magistrate may order them to be destroyed, and owner is liable to be prosecuted under section 273, Indian Penal Code.

368. Every medical practitioner who treats or knows of any epidemic, endemic, or dangerous infectious disease, except in a public hospital, must notify it to the President or to the Health Officer.

369. Power of entry to prevent spread of disease.

370. Carriages for conveyance of patients may be provided.

371. Power of removing to hospital patient suffering from dangerous infectious disease, who is without proper lodging or who is lodged in a room occupied by more than one family.

372. Power to order disinfection of buildings or articles at expense of owner, or in case of owner's inability, of municipal fund.

373. Disinfecting apparatus may be provided, also places for washing infected articles, and such articles may be destroyed with or without compensation.

374. Penalty of Rs. 50 for giving, lending, selling or transmitting infected articles.

375. Similar penalty for person suffering from a dangerous infectious disease who enters or is conveyed in a public vehicle without proper precaution.

377. Penalty of Rs. 200 for letting infected rooms.

378. The Governor in Council may notify that vaccination is compulsory under approved bye-laws.

Sect. 379. Burial and burning grounds must be registered,
381. and a list of them be published annually.
388. When dangerous to health may be closed.
390. Graves must be 5 feet deep with not less than 2 feet between them ; a corpse must be buried within 6 hours after being brought to burial ground ; old graves must not be re-opened without leave ; burning must be begun within 6 hours after a body is brought to burning ground ; cremation must be complete and cloths must be burnt ; corpses carried through street must be decently covered and not left on highway ; under a penalty of Rs. 50.
392. Commissioners to provide burial or burning grounds.
394. Commissioners must keep register of births and deaths and appoint registrars.
397. Every registrar shall inform himself of and register every birth and death in his district.
398. Information of every birth to be given within a week by the father or mother, or in case of their death or inability, by some one who was present or in attendance at the birth.
399. Information of death to be given, within 24 hours, by some one who was present or in attendance, or in default by the occupier or some person living in the house.
401. Persons performing funeral to give information.
402. Rs. 20 penalty for neglect.
404. Sum not exceeding annas 4 may be given to informer.
413. Power to make bye-laws.
414. Which must be confirmed by Government.

THE MADRAS DISTRICT MUNICIPALITIES ACT (1884).*

113. The funds raised under this Act are applicable to the following purposes :—

(i) construction and maintenance of streets, bridges, and other means of communication ;

(ii) maintenance of hospitals, dispensaries, asylums, markets, drains, sewers, water-works, tanks, wells, training of medical practitioners and vaccinators, sanitary inspection of towns and villages, registration of births and deaths, lighting and cleansing of streets, and other works of a similar nature ;

---

* This Act supersedes *The Towns Improvement Act*, 1871.

(iii) diffusion of education, maintenance of schools wholly or by grants-in-aid, training of teachers;
(iv) other measures of public utility to promote safety, health, comfort, or convenience of people;
(v) and (vi) payment of salaries and expenses.

Sect. 32. The Chairman is the chief executive officer of the Municipal Council.

33. The Collector of the District may execute any resolution on default of the Chairman.

34. The Collector has inspecting power.

35. The Government or the Collector may suspend action.

75. Water-tax on buildings and lands.

125. Provision and maintenance of hospitals and dispensaries.

129. Provision for gratuitous vaccination.

133. Government may declare vaccination compulsory.

134. When every child over six months and under ten years of age must be vaccinated.

138. Penalty Rs. 50 and Rs. 10 a day for disobedience of notice to have child vaccinated.

142. Prohibition of inoculation. Penalty 3 months' imprisonment or fine of Rs. 200 or both.

143. Municipal Council shall, so far as funds admit, provide a sufficient supply of water fit for domestic use.

144. The Council may, with the sanction of Government, construct new works, and may maintain, close, or alter existing works.

152. Penalty of Rs. 500 and Rs. 100 a day for fouling water by offensive trades.

154. Council may set apart tanks, wells, &c., for drinking purposes, and for bathing and washing animals or clothes.

155. Penalty for fouling drinking-water sources, public or private, in any way, Rs. 20.

156. Power to require private well, tank, stream, &c., to be cleaned and kept in order or to be closed, if unfit for drinking.

157. Maintenance and repair of streets.

175. Watering and lighting streets.

179. Before a new building is erected application must be made with a statement of dimensions, level of foundations and ground floor, means of ventilation, drainage, and privies, and such other particulars as may be required. If disapproved of Municipal Council to state their views.

186. Council may require filthy buildings or lands to be cleansed, and lands overgrown with noxious vegetation to be cleared. In default work may be done at owner's expense.

Sect. 187. Power to require buildings crowded together in an insanitary way to be altered or pulled down, or to execute such work.

188. Licenses for offensive or dangerous trades, cattle yards, to contain 10 head of cattle or pigs, or 20 sheep or goats, public stables, &c., and bake-houses.

191. Municipal Council to provide slaughter-places or houses. Slaughter-houses and butchers' shops must be licensed and license-fees charged for all animals slaughtered.

192. Penalty for slaughtering elsewhere or drying skins so as to cause nuisance, Rs. 20.

194. Municipal Council may provide markets.

196. Private markets may be licensed.

206. Municipal Council shall, so far as funds admit, provide and maintain a sufficient number of public latrines and urinals.

207. Owner or occupier of a building or of ground on which a block of six or more huts stands, may be required to provide or alter and properly maintain a latrine.

208. Latrine must be provided when more than 20 labourers are employed.

209. Power to contract for private scavenging.

210. Drainage works to be constructed under the direction of Municipal Council.

213. No drain, privy or cess-pool shall be constructed without permission of Council.

214. Branch drains, private latrines, cess-pools, &c., to be under the control of Council and kept in order at cost of owners.

216. Cleansing of streets.

217. Providing rubbish depôts and dust-bins. Fine of Rs. 10 for deposit elsewhere.

218. Providing covered vehicles and depôts for night-soil. Similar fine for deposit elsewhere.

219. Provision of movable temporary receptacles in houses if required.

221. Penalty of Rs. 20 and Rs. 5 a day for keeping filth more than 24 hours on premises and for neglecting to keep latrine in proper order.

222. Penalty of Rs. 10 for allowing sewage to flow into street.

224. Penalty of Rs. 20 for throwing rubbish into sewers.

225. Penalty of Rs. 5 for not preventing child under 12 from committing nuisance in street.

Sect. 226. Municipal Council may take proceedings to prevent overcrowding in buildings. Penalty Rs. 10 a day for neglect of Magistrate's order.

227. Power to cleanse or fill up stagnant pools or wells.

228. Owner may be required to cleanse, fence, repair or fill up tank or well or drain of stagnant water.

230. Stray pigs and dogs may be destroyed.

231. Power of entry to prevent spread of disease, and to disinfect houses or articles at owner's or at Municipal expense.

232. Places for washing infected articles may be appointed or such articles may be destroyed. Penalty for washing elsewhere, Rs. 50.

233. Chairman may, on a medical certificate, order removal to hospital of patients without proper accommodation or lodged in a room occupied by more than one family.

234. Municipal Council to provide burning or burial grounds.

235. Burning and burial grounds to be registered.

238. Penalty for disposing of corpse elsewhere, Rs. 100.

241. Same as 390 of Madras Municipal Act.

243. Municipal Council to keep register of births and deaths and appoint registrars.

247. Father or mother or some one present at birth to give information within a week. Some one present at death, or in attendance during illness, or occupier of house, to give information of death within 24 hours.*

255. The Municipal Council is empowered to make bye-laws which must be confirmed by Government.

The Madras Local Boards' Act, 1884.

District Boards,† Taluk Boards and Panchayats have been constituted by this Act for the purposes of local Government, including village and district sanitation.

144. Government may, from time to time, make rules as to the duties, responsibilities and mutual relations of those bodies.

The following is a brief account of the constitution of Local Boards and Panchayats as formed under this Act.

---

* It is noticeable that no penalty for default is contained in the Act, though such was provided in the Local Boards' Act, 1871. But under section 255 of the present Act a bye-law may provide a penalty of Rs. 50.

† District Boards take the place of the Local Fund Boards of the Local Funds Act, 1871.

District Boards.

Authority over each district is vested in a District Board, which consists of a President and at least 24 members. The Collector is *ex-officio* President, unless Government has authorized the election of the President; and every revenue officer in charge of a division is a member. The other members may all be appointed by Government or be in part elected; but not more than one-fourth may be officials.

Taluk Boards.

The local authority of each taluk is a Taluk Board, which is in a manner subordinate to the District Board. The revenue officer in charge of the division of the district in which the taluk is situated is *ex-officio* President, unless Government has authorized the election of the President. The Board must consist of at least 12 members, who may be appointed wholly by Government or partly by election. Not more than one-third may be officials. Meetings must be held at least once a month. A Board may be abolished by order of Government. The President of a Local Board is its chief executive officer.

Panchayats.

Any village or group of villages may, from time to time, be constituted a *union* by notification of Government. *Major unions* have a population over, *minor unions* under, 5,000. Each union is controlled by a *Panchayat* of not less than five members. The headman of each village in a union is *ex-officio* a member. The other members may be appointed by Government or be in part elected. Government may appoint a chairman or authorize his election.

A Panchayat is the agent of and under the control of the Taluk Board.

Duties of Local Boards.

Sect. 95. Every Local Board shall, so far as funds admit, provide for:—

(i) the construction and maintenance of streets, bridges, and other means of communication;

(ii) the planting and preservation of trees by roads and on public places;

(iii) the construction and repair of hospitals, dispensaries, markets, drains, sewers, water-works, tanks, wells, training of medical practitioners and vaccinators, sanitation of towns and villages, and other works of a similar nature;

(iv) education, school-houses, maintenance of schools wholly by grants-in-aid, inspection of schools, training of teachers;
(v) relief works in famine or scarcity;
(vi) other measures of public utility to promote safety, health, comfort or convenience;
(vii) and (viii) payment of salaries and expenses.

Sect. 98. The President of the Taluk Board may cause obstructions and encroachments to be removed.

99. Private sources of drinking-water may be cleansed, fenced or closed.

101. Unwholesome buildings or lands may be cleansed or drained. In default of the owner this is to be done at the expense of the Taluk Fund.*

102. District Board to provide for gratuitous vaccination.

106. Government may proclaim vaccination compulsory in any district from a specified date.

107. All unprotected children over 6 months and under 10 years of age must then be vaccinated.

112. Penalty of Rs. 50 and Rs. 10 a day for disobedience of Magistrate's order to have child vaccinated.

117. President of Taluk Board may contract for private scavenging.

Duties of Panchayats.

141. In all unions—

(*a*) cleansing the village streets, drains, tanks, wells, and other public places in the union;
(*b*) generally doing such things as may be necessary for the preservation of public health.

In a major union—

(*a*) making and repairing the village streets and drains in the union;
(*b*) constructing and repairing such tanks and wells and other works as will supply the inhabitants of the union with sufficient water for domestic use.

INDIAN PENAL CODE.

(*Act XLV of* 1860 *amended by Act VIII of* 1882.)

CHAPTER XIV. *Of offences affecting the public health, safety, convenience, decency and morals.*

268. A person is guilty of a public nuisance, who does any act, or is guilty of an illegal omission, which

* Some amendment appears to be needed here.

causes any injury, danger or annoyance to the public or to the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right.

A common nuisance is not excused on the ground that it causes some convenience or advantage.

Sect. 269. A negligent act likely to spread the infection of any disease dangerous to life is punishable by 6 months' imprisonment, which may be with hard labor, or by fine, or both.

270. A malignant act likely to spread the infection of any disease dangerous to life is punishable by 2 years' imprisonment which may be with hard labor, or by fine, or both.

271. Disobedience to a quarantine rule punishable by 6 months' imprisonment, or fine, or both.

272. Adulteration of food or drink intended for sale, so as to make it noxious, is punishable by imprisonment for 6 months, or a fine of Rs 1,000, or both.

273. Sale of noxious food or drink (knowingly) is punishable by similar penalties.

274. Adulteration of drugs so as to lessen their efficiency or change their operations or make noxious carries similar penalties.

275. Sale of adulterated drugs or (276) of any drug as a different drug or preparation is similarly punishable.

277. Fouling the water of a public spring or reservoir * is punishable by 3 months' imprisonment, or fine of Rs. 500, or both.

278. Making atmosphere noxious to health is similarly punishable.

284. Negligent conduct with respect to any poisonous substance is punishable by 6 months' imprisonment, or fine of Rs. 1,000, or both.

290. Punishment for public nuisance (in any case not otherwise punishable by this Code), fine up to Rs. 200.

291. Continuance of nuisance after injunction to discontinue is punishable by 6 months' imprisonment, or fine, or both.

Code of Criminal Procedure (*Act X of* 1882).

54. Any police officer may, without an order from a Magistrate, and without a warrant, arrest any

* This does not include a river.

person who has been concerned in any cognizable offence, or against whom a reasonable complaint has been made, or credible information has been received or a reasonable suspicion exists, of his having been so concerned.

Public Nuisances.

Sect. 133. A conditional order for the removal of a nuisance, obstruction, or injurious trade, may be made by a District, Sub-divisional or duly empowered First-class Magistrate.

135. Person to whom order is addressed must obey it, or show cause against doing show, or apply to the Magistrate for a jury to try it.

136. On default person is liable to penalty under section 188, Penal Code, and order shall be made absolute.

140. When an order has been made absolute the person is to be required to perform the act within a given time ; on default he is liable to penalty by section 188, Penal Code.

If such act is not performed within the time fixed, the Magistrate may cause it to be performed, and may recover the cost from the person.

142. To prevent imminent danger or injury of serious kind to the public, a Magistrate making an order under section 133 may issue such injunction as may be required. In default he may adopt such means as he thinks fit to prevent it.

143. A Magistrate may order any person not to repeat or continue a public nuisance, as defined in the Indian Penal Code or any special or local law.

144. An absolute order may be at once issued in urgent cases of nuisance.

149. Every police officer shall interpose to prevent the commission of any cognizable offence.

151. If necessary, he may arrest without warrant to prevent commission of any such offence.*

155. Non-cognizable offences can only be investigated by, or under orders of, a Magistrate.

---

* Cognizable offences under Penal Code, sections 269, 277, 291.

APPENDIX.

ON THE IMMEDIATE TREATMENT OF ACCIDENTS AND SUDDEN ILLNESSES.

Bleeding from Wounds.

The person should be placed lying down and the wounded part be kept uppermost; if the wound be on a limb, the limb should be raised.

A pad of cloth, dipped in cold water, should be placed over the wound and retained by a bandage applied loosely.

If blood continues to ooze out in any quantity, a strong solution of *alum* may be used instead of water; or a small pad of cloth may be placed in or on the wound, a second larger pad over it, and a bandage be applied firmly over this.

Arterial bleeding, which occurs when a large artery (blood-vessel) is wounded, is the most dangerous kind of bleeding. The bleeding is very rapid and the blood often spurts out in jets.

The patient should be placed lying down and *firm pressure* be made with one finger on the point from which the blood comes.

If, on taking the pressure off after a few minutes, the bleeding recurs, and if the wound be in a limb, pressure must be applied to the main artery which supplies the limb with blood. The main artery of the arm may be felt throbbing on the inner side of the arm a little below the armpit; that of the leg, which is not so easily felt, is situated on the front of the thigh a the groin and passes round to the inner side of the thigh as it goes down, being on the inner side about half way between the hip and the knee. The bleeding will stop when the artery is properly compressed, and the place where pressure is applied should be changed until this occurs. Pressure may be made in the first place with the two thumbs, while a firm pad is being prepared. This may be made with a cork or a piece of wood or a smooth stone wrapped in cloth, and it should be very firmly tied over the artery with a bandage (a broad strip of cloth, not a string) wound several times round the limb, or a knot may be tied in the middle of a handkerchief, which is tied round the limb, the knot serving as a compression pad over the artery.

Wounds and Burns

should be treated in the simplest possible manner, a piece of folded cloth, wetted with clean water, being placed over the wound and kept on by a bandage or handkerchief. For burns the cloth may be soaked in oil instead of water.

Fractures of Bones.

When the bones of the limbs are broken the injury is generally easily recognised by loss of power in the limb, shortening or distortion, local pain and swelling, movement at the seat of fracture when the limb is gently moved from side to side.

Great care must be taken in moving a person with a broken limb, lest the broken ends of bone be made to injure the flesh or even the skin, in the latter case converting a simple into a compound fracture.

A *simple* fracture is breakage of a bone in one place without wound of the skin in connection with it. A *compound* fracture is a fracture with a skin wound in communication with it. A *comminuted* fracture is a splintering or crushing of the bone.

When a limb-bone has been broken the patient must be gently laid on his back and not moved until the limb has been placed in *splints*. These are light boards or sticks which are bandaged to the limb in such a way as to prevent motion of the bones at the place of breakage. Pieces of stick or bamboo or an umbrella may be used as temporary splints. These should first be wrapped in cloth. Cloths should be removed from the limb, sleeves or trowsers being cut. The limb should then be gently and slowly pulled out to its proper length, and be kept so while the splints are bandaged on, one on each side, and a third, if a flat one is procurable, behind. If the thigh-bone be broken the outside splint should reach from the waist to below the knee and be bound by a band round the hips as well as by bandages lower down. Splints may be bound to the limb by strips of bandage at intervals of three or four inches.

When the collar-bone (bone at side of neck) is broken, the person should be simply kept lying on his back, without a pillow and with his arm close to his side.

For removal a flat-bottomed stretcher should, if possible, be employed. A door may be taken off the hinges and used for the purpose.

Dislocation

or displacement of the bones at a joint is recognised by immediate deformity and stiffness and loss of motion at the joint. Pain and swelling may be considerable. The person should

be gently removed in whatever position is least painful, and a medical man should be summoned as quickly as possible.

Sprains

are injuries to joints caused by twists or unnatural strains, which may cause rupture of some of the ligaments which bind the bones together around a joint or injury to the smooth membrane which lines the interior of the joint. A sprain is attended with great pain and inability to use the joint, followed by swelling and inflammation. The part should be kept raised and in a comfortable position, and a thin cloth, wetted with cold water, be applied to it.

Internal Injuries

can only be treated by a medical man. They are very likely to be caused by a fall from a height, by a weight falling on the body, or by being run over by a vehicle. After any such accident it is always wise to keep the person at perfect rest for some days. If there be shock, and prostration or fainting after an accident, the person should be kept lying on his back and be carried away very gently on a stretcher.

Insensibility

may result from many different causes. The commonest are here noticed.

Fainting is due to failure of the heart's action, from shock, bleeding, fasting, fatigue, &c. The person's lips become pale, a cold sweat breaks out on his forehead, he may be restless for a minute or two, sometimes sighs, and then becomes unconscious, and falls, if standing or sitting. The pulse is altogether or nearly imperceptible. He should be kept lying down *with his head low.* The hands may be bathed in cold water. When able to swallow, any stimulant may be administered: spirit and water or warm milk or coffee.

Apoplexy is most likely to occur in elderly people. The patient becomes suddenly insensible, and, if standing or sitting, drops to the ground; he sometimes has convulsions, which may affect only one side; he breathes heavily, with snoring, and puffing out of one or both cheeks; one arm may move if pinched, while the other does not; the pulse is slow and full. He must be placed lying down *with the shoulders and head well raised,* all bands about the neck being removed. A handkerchief, wet with cold water, may be applied to the head. No stimulants, nor food, should be given. Medical advice should be obtained.

Epilepsy or "fits." Some persons are subject to "fits" at intervals. They fall down suddenly, with or without a scream, the limbs are violently agitated, the face is contorted and livid and foam comes from the mouth. When the fit is over the patient may recover consciousness at once or fall into a deep sleep. Nothing can be done in the way of immediate treatment except to place a cork or bit of wood between the patient's teeth to prevent him from biting his tongue. His limbs should not be held.

Concussion of the brain or "stunning" may result from a fall on the head. The patient lies with his eyes shut and lips pale and breathes very slowly. He *may* answer if spoken to loudly and lapse into unconsciousness again. Vomiting is common. The treatment should consist of perfect rest, the head being moderately raised. Stimulants are injurious.

Drunkenness.—The patient lies unconscious or half conscious, the face is often puffy and respiration heavy, and there is a smell of liquor from the breath. It is not always easy to distinguish drunkenness from apoplexy. No treatment is generally required; but the patient's throat may be tickled inside with a feather to induce him to vomit.

Opium poisoning resembles drunkenness, but the *pupils* (black central spots in eyes) *are very small* and there is probably no smell of liquor. An emetic of mustard or salt should be given, and the patient be kept awake.

Suffocation, due to descent into old dry wells, &c., must be treated as *drowning, q.v.*

Drowning.

Persons whose breathing has stopped and who are apparently dead owing to a short immersion in water or a suffocating gas may often be restored by *artificial respiration.* If the rescue has been speedy enough to admit of any hope, artificial respiration should be persevered with for at least an hour before the case is given up.

In case of drowning the throat should first be cleared by turning the patient on his face, raising his forehead with one hand, so as to bend his neck well back,* and wiping out his mouth.

He should then be placed on his back with a pillow or bundle of clothes under his shoulders, his head hanging backwards as far as possible.

---

* Medical readers are referred to a paper by Dr. Howard, of New York, read before the Medical Society of London in October 1888, on *a new and only way of raising the epiglottis.*

The chest should then be well rubbed, and the nostrils may at the same time be tickled by a feather or snuff.

If this does not *speedily* excite respiration, the operator should kneel astride the patient's body and placing both his hands spread out on the patient's chest, one on each side, press the chest slowly and firmly so as to squeeze out the air contained in the lungs, the pressure being then not too rapidly relaxed, so as to allow the chest to expand again and draw in air. This should be repeated, imitating as nearly as possible the natural movements in strong respiration, about fifteen times in a minute—once in four to five seconds.

At the same time assistants may help by rubbing the arms and legs with hot cloths.

If, after an hour, there is no sign of returning natural respiration, the patient must be regarded as beyond recovery.

Internal Poisoning.

Poisons taken by the mouth may be (1) *narcotic* or sleep-producing, or (2) *irritant*. The latter cause pain, vomiting and purging.

The first object is to wash out the stomach, even if the person has already vomited. The stomach-pump and certain modes of special treatment can only be used by a medical man, but the following emetics may be employed:—

Copious draughts of tepid water.
Salt and water.
Mustard and water (not in irritant poisoning).
Tickling the throat with the finger or a feather.
Ipecacuanha, a large spoonful.
Zinc sulphate, a tea-spoonful in water.

Narcotic poisoning.—If able to swallow, give an emetic of mustard. Hot and strong coffee should be given, the limbs should be rubbed, the patient be forced to walk about and be kept awake.

Irritant poisoning.—If vomiting has not occurred, tickling the throat or an emetic of ipecacuanha may be resorted to. Copious draughts of tepid water or cunjee water should be administered. Milk, milk and flour, eggs beaten up and other demulcent substances may be given as food.

Antidotes.—The following is a useful general antidote:—

Magnesia, 88 parts.
Animal charcoal, 44 parts.
Saturated solution of sulphate of iron, 100 parts.
Water, 800 parts.

The magnesia and animal charcoal are best kept mixed in a dry state, and they should be weighed out and preserved in a bottle. The 100 parts of iron solution should be kept in a second bottle. When required for use, the iron solution is mixed with eight times its bulk of water, the magnesia and charcoal being then stirred up with it.

The dose is a wine-glassful frequently repeated.

Bites and Stings

may occasion general poisoning by entrance of the poison into the blood or local poisoning from irritation of the tissues at the place of injury.

A large number of the smaller (principally invertebrate) animals possess a poisonous secretion which they inject into the skin by means of hollow fangs or stings, or by simple bites.*

For the present purpose it will be sufficient to allude to (1) *snake-bite*, (2) *stings* of scorpions and various insects, including *bites* of centipedes, spiders and insects, (3) *bites of rabid dogs* and other animals.

In *snake-bite* the treatment must be immediate and be directed "to endeavour to prevent the entry of the virus into the circulation; and to neutralize it in the wound before it is absorbed." If the bite be on a limb, a thin strip of cloth must be tied very tightly round the limb above the bite, and the bitten spot should be at once cut out or be destroyed by a hot iron or a strong caustic. Potassium permanganate or caustic potash may also be applied to the part to destroy venom. Stimulants should be given freely by the mouth.

Stings are often very painful, but rarely fatal. Alkalis, such as ammonia or solution of caustic soda or potash, are probably the best local applications. Cocaine or a little strong carbolic acid may be applied to allay pain.

Bites of mad animals should be treated by washing and then burning the wound with a hot iron inserted into it or a strong caustic, such as caustic potash or nitric acid.

---

* Sir Joseph Fayrer gives an excellent account of *Venomous Animals* in Quain's Dictionary of Medicine.

INDEX.

A.

B.

U.

V.

W.

Y.

Z.